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ANALYSIS OF THE IMPACT OF A 270 VDC POWER SOURCE ON THE AVIONIC--ETC(U)
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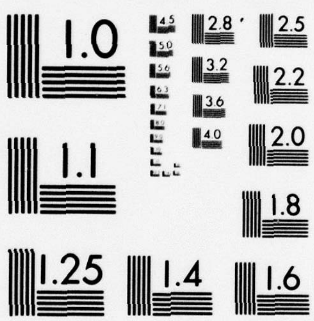
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270 Vdc IMPACT STUDY

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ANALYSIS OF THE IMPACT OF A 270 VDC POWER SOURCE ON THE AVIONIC POWER SUPPLIES IN THE S-3A AIRCRAFT

Prepared under Naval Air Development Center Contract
No. N62269-78-C-0007

FOREWORD

This report is the result of an analytical study on the impact of a 270 Vdc primary power on avionic equipment power supplies performed by the Advanced Avionics Department of the Lockheed-California Company. The work was sponsored by the Naval Air Development Center under the direction of Howard Ireland, Project Engineer.

Invaluable assistance was provided by Engineered Magnetics Division of Gulton Industries, Inc., in their analysis of 400 Hz S-3A power supplies and preparation of preliminary design, weight, and efficiency estimates for 270 Vdc replacement power supplies.

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SECTION 1

INTRODUCTION, SUMMARY, AND CONCLUSIONS

1.1 INTRODUCTION

The weakest link in avionic system hardware has traditionally been power supply circuitry, which exhibits abnormally high failure rates when compared to other electronic circuitry. In general, this is due to the prevailing 115/200V, 400 Hz design technology and the resulting large amount of power dissipated in power supply modules. With the advent of 270 Vdc primary electrical power systems, new dc/dc converter design technology can be used to increase power supply efficiency and reduce the weight and power losses of power supply hardware. This results in increased reliability and maintainability features and reduced life cycle cost (LCC).

The objective of this analysis was to determine the total platform impact on an S-3A avionic suite outfitted with 270 Vdc switched mode regulators in lieu of standard 115/200V, 400 Hz transformer coupled series regulators and to quantify the resulting impact in terms of changes to aircraft weight, mission performance, fuel usage, reliability, and LCC.

The results, summarized in tabular form, represent the exercise of the many engineering disciplines within the Lockheed advanced design groups and include 270 Vdc power supply design work performed under subcontract by the Engineered Magnetics Division, Gulton Industries Corporation, Hawthorne, California.

1.2 SUMMARY

1.2.1 Aircraft, Systems, and Mission Definition

The baseline aircraft selected for this analysis is a Lot VII Production S-3A, Navy Serial No. 160567, as of 15 November 1976, for which comprehensive weight and performance data was assembled. It is identified in Table 1-1 as BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D." The mission shown corresponds to a specification mission for which the S-3A was originally designed and is maintained as a constant in this analysis. The avionic suite in the baseline S-3A is air cold plate-cooled by 80°F cabin air and by ambient (103°F maximum) forced air. Cooling of the cabin air is provided by an air cycle environmental control system (ECS) obtaining its input from engine compressor bleed air and auxiliary power unit (APU) air.

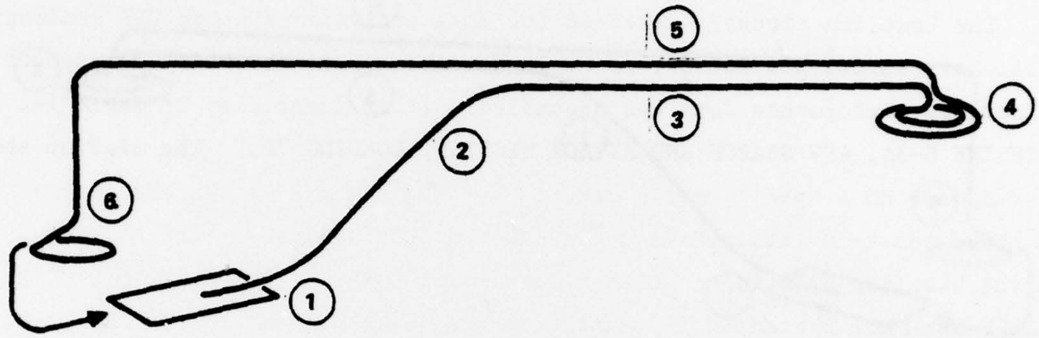
To quantify the results of the analyses in this summary, two theoretical S-3A aircraft were computer derived. The first, identified in Table 1-2 as OPTIMIZED S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D," CONFIGURATION 2, represents an S-3A optimized in size and weight as the result of subsystem improvements, performing the same mission with 270 Vdc power supplies, air cold plate cooled with a reduced capacity air cycle ECS, and supplied from a 270 Vdc generating system.

The second theoretical S-3A aircraft, identified in Table 1-3 as OPTIMIZED S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D," CONFIGURATION 3, represents an S-3A also optimized in size and weight, performing the same mission with 270 Vdc power supplies, but vapor expansion cold plate cooled with a vapor cycle (Freon) ECS, and supplied from a 270 Vdc generating system.

1.2.2 Total Platform Impact

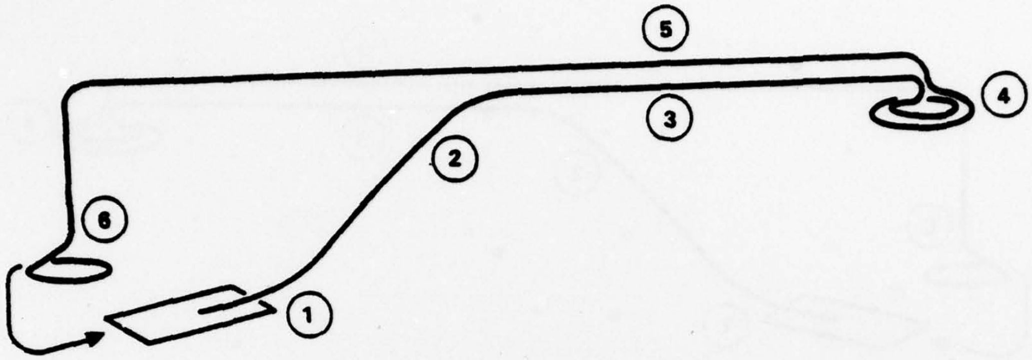
To determine the total platform impact on the S-3A aircraft as the result of changing the present avionic power supplies operating from 115/200V, 400 Hz power, to functionally equivalent power supplies operating from 270 Vdc power, the analytical progressions described in the following paragraphs were followed.

TABLE 1-1. BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D" (SPECIFICATION AIRCRAFT)



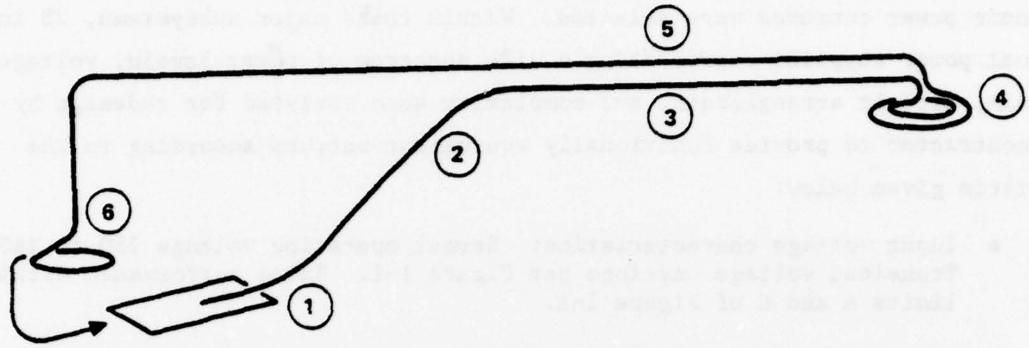
Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-Up & Takeoff	44,286	-	0	0.08	460	-
2. Climb	43,826	220	0	0.32	1149	99
3. Cruise Out at Optimum Altitude	42,677	355	36,100	0.73	1292	257
4. Loiter on Station	41,388	370	38,000 to 40,000	4.5	7624	0
5. Cruise Back at Optimum Altitude	33,760	356	40,000	1.02	1464	356
6. Reserve Loiter	32,296	160	0	0.33	496	-
5% Initial Fuel Reserve	31,800	-	-	-	657	-
Totals: Mission Time (Items 2 through 5)						6.57 Hr
Mission Fuel (Items 1 through 5)						11,989 Lb
Fuel Load						13,142 Lb
Radius of Operation						356 NM

TABLE 1-2. OPTIMIZED S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D", CONFIGURATION 2 Δ WT - 400.4 LB PAYLOAD



Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-Up & Takeoff	42,848	-	0	0.08	443	-
2. Climb	42,405	220	0	0.32	1110	99
3. Cruise Out at Optimum Altitude	41,297	356	36,100	0.73	1244	257
4. Loiter on Station	40,051	370	38,000 to 40,000	4.5	7360	0
5. Cruise Back at Optimum Altitude	32,691	354	40,000	1.02	1413	356
6. Reserve Loiter	31,278	160	0	0.33	478	-
5% Initial Fuel Reserve	30,800	-	-	-	634	-
Totals: Mission Time (Items 2 through 5)						6.57 Hr
Mission Fuel (Items 1 through 5)						11,570 Lb
Fuel Load						12,683 Lb
Radius of Operation						356 NM

TABLE 1-3. OPTIMIZED S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D", CONFIGURATION 3
Δ WT - 485.0 LBS PAYLOAD



	Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1.	Warm-Up & Takeoff	42,540	-	0	0.08	441	-
2.	Climb	42,099	220	0	0.32	1100	99
3.	Cruise Out at Optimum Altitude	40,999	355	36,100	0.73	1256	257
4.	Loiter on Station	39,743	370	38,000 to 40,000	4.5	7276	0
5.	Cruise Back at Optimum Altitude	32,467	356	40,000	1.02	1414	356
6.	Reserve Loiter	31,053	160	0	0.33	475	-
	5% Initial Fuel Reserve	30,578	-	-	-	630	-

Totals:	Mission Time (Items 2 through 5)	6.57 Hr
	Mission Fuel (Items 1 through 5)	11,487 Lb
	Fuel Load	12,592 Lb
	Radius of Operation	356 NM

1.2.2.1 Power Supply Weight, Volume, Efficiency, and Reliability

Seven major avionic subsystems accounting for 71.6 percent of the total avionic power consumed were selected. Within these major subsystems, 28 individual power supplies representing a wide spectrum of power levels, voltage levels, circuit arrangements, and complexity were analyzed for redesign by the subcontractor to provide functionally equivalent outputs according to the criteria given below:

- Input voltage characteristics: Normal operating voltage 250 to 280. Transient voltage envelope per Figure 1-1. Rated performance within limits A and C of Figure 1-1.
- Maximum ripple: 12V peak to peak with frequency components within the limits of Figure 6, MIL-STD-7016B.
- Cooling, Configuration 1: Forced air at the rate of 6 lbs/min/kW power dissipated. Maximum inlet temperature 80°F. Exhaust temperature 120°F.
- Cooling, Configuration 2: Conduction to infinite cold plate with interface maintained at 5°C (41°F).
- EMI Control: Input/Output in accordance with MIL-STD-461A, Notice 3.
- Unit Reliability: Improvement goal - 8:1 per CNO (OR) WSL-04.

Changes in these power supply weights, volumes, and efficiencies are shown in Table 1-4. Changes in reliability are shown below.

The reliability changes presented in Table 1-5 were applied to the balance of power supplies in the seven avionic subsystems selected and, subsequently, to the remaining avionics subsystems in the aircraft. Table 1-5 also presents net weight changes of the total complement of aircraft power supplies. The reliability of the total aircraft power supply complement, summarized below, is reflected in LCC. See Figure 1-3.

	MTBF	MTBMA
Existing Power Supplies	276 hours	69 hours
270 Vdc Power Supplies, 80°F Air Cold Plate Cooled, Configuration 1	563 hours	141 hours
270 Vdc Power Supplies, 5°C Vapor Cold Plate Cooled, Configuration 2	1378 hours	345 hours

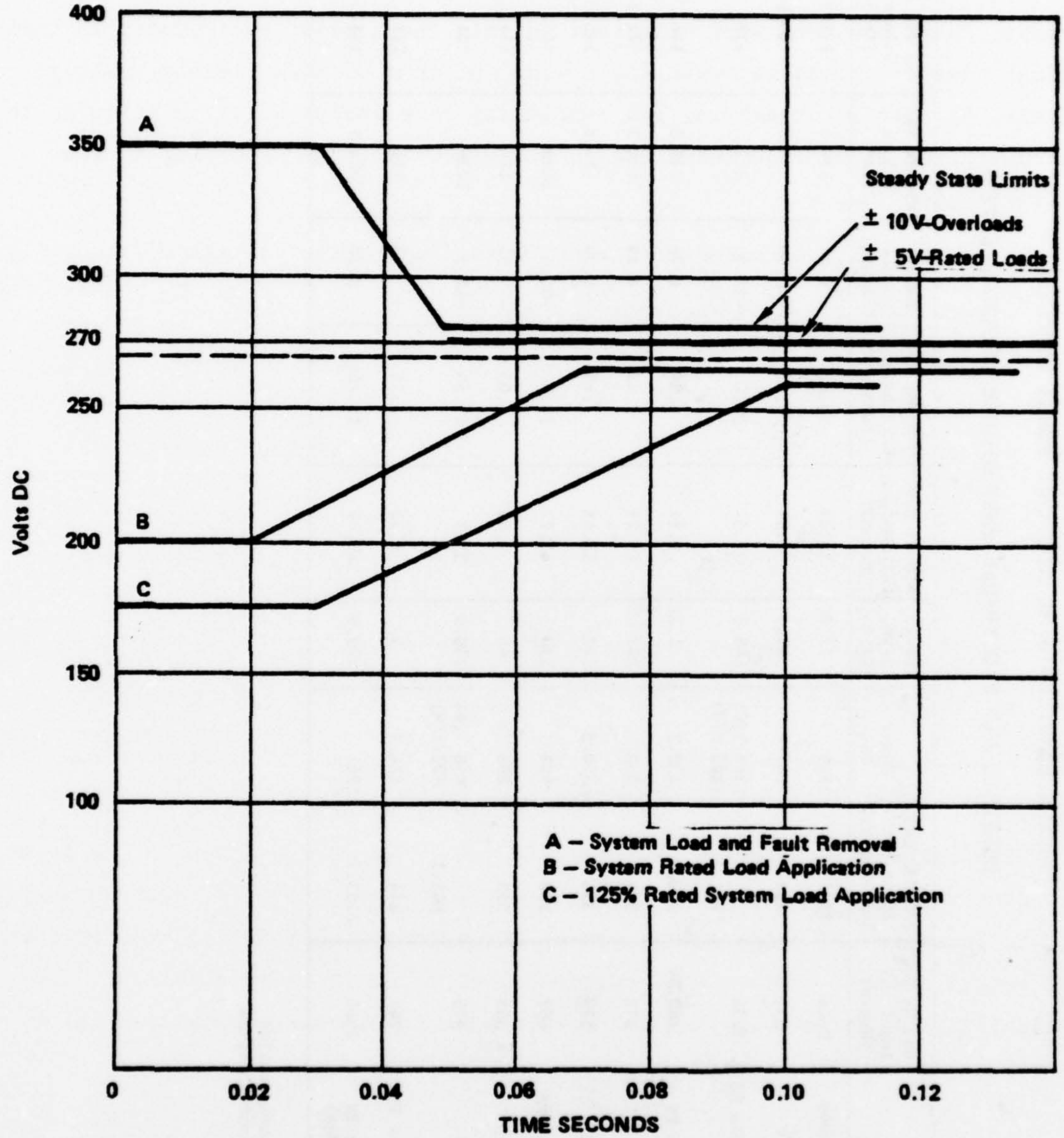


Figure 1-1. Power Supply Input Characteristics

TABLE 1-4. COMPARISON OF STATE-OF-THE-ART 270 VDC POWER SUPPLIES VERSUS EXISTING S-3A AIRCRAFT POWER SUPPLIES

PHYSICAL AND ELECTRICAL PERFORMANCE CHARACTERISTICS

Unit	400 Hz Sys Input Pwr (Watts)	270 Vdc Sys Input Pwr New (Watts)	Power Out	Power Saved (Watts)	400 Hz Sys Unit Weight (Pounds)	270 Vdc Sys Unit Weight (Pounds)	Delta Weight (Pounds)	400 Hz Sys Volume (In^3)	270 Vdc Sys Volume (In^3)	Delta Volume (In^3)
APS116 Radar HVPS	2606	2576	2319	27.0	18.32	14.05	- 4.27	124.3	171.9	+ 47.6
APS116 LVPS	231.3	189	167.4	42.3	2.57	1.97	-0.60	33.7	46.6	+ 12.9
ARC153A Multiple PS	2230	1781.2	1344.1(O) 1293.9(N)	448.8	39.3	28.0	-11.3	282	418	+136.1
AYN5A Multiple PS	183.96	180.0	139.2	1.38	9.12	6.34	- 2.78	225.6	144	- 81.6
ASA82 DGU PS	672	375	300	297	11.27	7.12	- 4.15	174.3	178.3	+ 4.0
ASA82 TACCO PS	577	395	350.5	182	11.49	7.49	- 4.00	116.8	146.8	+ 30.0
OL82A, PP-6671A PS	682	552	409	130	48.7	18.3	-30.4	1400	546	-854
OL82A, 5V PS	568	523	386	45	7.40	7.05	- .35	115	154.4	+ 39.4
AYK10 Line Reg	979	848.1	856 (O) 803.1(N)	130.9	31.7	13.50	-18.2	1008	384	-624
AYK10 Converter PS	247	244	174.9	3	6.32	6.35	+ .03	138	138	-
OR89C Multiple PS (PP-7197AA)	2365	2155.2	1961	209.8	19.46	10.76	- 8.70	273.5	178.3	- 95.2

(O) 400 Hz Configuration
(N) 270 Vdc Configuration

TABLE 1-5. AVIONICS POWER SUPPLY WEIGHT SUMMARY

Avionics System Components	Avionics System Power Supply Weights-Lbs		
Description	400 Hz Power Supplies - Air Cycle ECS Air Cold Plate Cooled - Baseline S-3A	270 Vdc Power Supplies - Air Cycle ECS Air Cold Plate Cooled - (Configuration 1)	270 Vdc Power Supplies Vapor Cycle ECS Vapor Expansion Cold Plate Cooled (Configuration 2)
Avionics Power Supplies	846.7	578.6	573.5
Total	846.7	578.6	573.5
ΔFrom Baseline S-3A	0	-268.1	-273.2

1.2.2.2 Electric Power System Weight Changes

The avionics connected load in the baseline S-3A is 26.783 kW. From improved 270 Vdc power supply efficiencies, the connected load is reduced to 21.999 kW in System Configuration 2. Although theoretically there is further reduction at the lower operating temperatures in System Configuration 3, the same reduction was assumed. S-3A mission operating experience indicates a utilization factor of 0.656, i.e., the ratio between total connected load and mission average (continuous) load, thus, resulting in a 3.138 kW reduction in mission average load. A detailed analysis of electric power system weight changes is given in Table 1-6. These values are based on the following criteria:

- Only that portion of the electric power system related to avionic power supply load changes is affected.
- Only that portion of the electric power system related to avionics power generation and distribution at the bus is changed from 115/200V, 400 Hz to 270 Vdc.
- A full performance mission can be completed with one generator inoperative, per SD-24K.
- The baseline system percentage generator reserve capacity is maintained.
- The baseline system generator per unit power/weight ratio is maintained.

TABLE 1-6. ELECTRIC POWER SYSTEM WEIGHT SUMMARY

Power System Components	Power System Component Weights - Lbs		
Element No. - Description	400 Hz Power Supplies - Air Cycle ECS Air Cold Plate Cooled - Baseline S-3A 75 KVA Generator Rating	270 Vdc Power Supplies - Air Cycle ECS Air Cold Plate Cooled - (Configuration 2) 70 KVA Generator Rating	270 Vdc Power Supplies - Vapor Cycle ECS Vapor Expansion Cold Plate Cooled (Configuration 3) 94 KVA Generator Rating
05 - Generators	178.8	166.9	225.1
07 - Gen Oil Cooling	34.2	31.9	43.1
08 - APU Generator	20.3	20.1	20.1
11 - Battery	1.5	1.5	1.5
12 - Battery Container	.5	.5	.5
17 - Transformer/Rect	24.3	23.2	23.2
22 - Transformers	6.5	6.5	6.5
23 - Power Diodes	3.2	3.2	3.2
25 - Generator Control	11.6	10.8	14.6
26 - Cutouts and Voltage Reg	2.4	2.3	2.3
28 - Switches, Rheostats	108.1	1 118.7	1 149.4
29 - Circuit Bkrs and Fuses	23.5	1 25.8	1 32.5
30 - Junct, Fuse, Dist Boxes	21.2	16.1	20.2
31 - Receptacles and Connectors	92.1	67.6	85.1
32 - Relays	43.0	2 42.0	2 52.9
33 - Wiring	122.5	93.0	117.0
34 - Conduit	10.6	9.8	9.8
35 - Ext Power System	4.6	4.3	5.8
37 - Lights, Interior	25.3	25.3	25.3
38 - Lights, Exterior	18.6	18.6	18.6
41 - Signal Devices, Lights	18.3	18.3	18.3
46 - Equip Supports, Wing	13.7	13.6	17.1
47 - Equip Supports, Tail	.6	.6	.6
48 - Equip Supports, Body	42.8	32.5	40.9
49 - Equip Supports, Nacelle	3.2	3.2	4.0
Total	831.4	756.3	937.6
Δ From Baseline S-3A	0	-75.1	+106.2

1 Weight Factor of Functionally Equivalent 270 Vdc Device = 2.9

2 Weight Factor of Functionally Equivalent 270 Vdc Device = 1.8

1.2.2.3 Environmental Control System Weight Changes

Because a large percentage of avionic cooling in the baseline and Configuration 2 aircraft systems is provided by cabin overboard air, a reduction of 11.8 percent only in the theoretically required ECS design cooling capacity to maintain the same temperature rise in the avionic power supplies was obtained in the Configuration 2 aircraft as the result of reduced 270 Vdc power supply heat dissipation. The 11.8 percent reduction in Required ECS design cooling capacity corresponds to a change from 25.651 kW to 20.867 kW total avionic system dissipation on the basis of maximum avionic utilization (utilization factor = 1.0) in System Configuration 2.

In the optimized S-3A Configuration 3 System, the change in total avionic system maximum utilization dissipation is the same, but because of the use of a vapor cycle ECS and vapor expansion avionic power supply cold plate cooling, the weight of the ECS system is significantly reduced. The effects of these changes on ECS weight are shown in Table 1-7.

1.2.2.4 Engine Performance

The reduction in engine compressor bleed extraction (11.8 percent) and the reduction in generator power extraction (9.5 percent) associated with the use of 270 Vdc power supplies in the optimized S-3A, Configuration 2 results in an improvement in engine specific fuel consumption (SFC) of 0.6 percent. Although the generator power extraction in the optimized S-3A, Configuration 3 increases as a result of the use of an electrically driven vapor cycle ECS, engine compressor bleed air extraction is greatly reduced, the net effect being an SFC improvement of 3.4 percent. The reduced fuel consumption is reflected in aircraft design gross takeoff weight (GTOW), mission performance, and the effects on LCC are specifically identified in Figure 1-3.

1.2.2.5 Aircraft Design Takeoff Gross Weight (DGTOW)

The cascading effects of changes in the S-3A avionic system power supplies as the result of operating from a 270 Vdc power source were resolved in terms of fixed weight changes within each affected aircraft system, i.e., the avionics, ECS, and electric power systems. From previous work, the weight

TABLE 1-7. ECS COOLING SUBSYSTEM WEIGHT SUMMARY

ECS Components	Environmental Control System Component Weights - Lbs		
Description	400 Hz Power Supplies - Air Cycle ECS Air Cold Plate Cooled - Baseline S-3A	270 Vdc Power Supplies - Air Cycle ECS Air Cold Plate Cooled - (Configuration 2)	270 Vdc Power Supplies - Vapor Cycle ECS Vapor Expansion Cold Plate Cooled (Configuration 3)
Cooling Components -	307.6	271.3	214.6
Compressors Ht. Exch/Condensers Turbines Evaporators Fans Water Separators Valves Plumbing Supports			
Ducting Components -	326.3	306.4	101.3
Ducts Insulation Supports			
Fixed Components -	57.5	57.5	57.5
Scoops Valves Gaspers Controls Ground Connections			
Total	(1) 691.4	635.2	373.4
Δ From Baseline S-3A	0	-56.2	-318.0

(1) Represents cooling portion of total S-3A ECS only. Total S-3A ECS weight including cabin pressurization, ventilation, heating, and anti-icing components is 956.8 lbs.

coefficients of these aircraft systems in relation to the gross weight of the baseline aircraft performing the specified mission were known. By scaling the fixed weight components of the aircraft according to their coefficients over a 1000 pound range, a weight growth factor curve valid for the range of anticipated fixed weight changes was derived. This curve, shown in Figure 1-2 is applicable only in the process of ascertaining the effect of fixed weight changes (as for the aircraft systems analyzed) on gross aircraft weight for an aircraft during its design phase in which design parameters can be varied. The aircraft referred to as optimized S-3A aircraft in this summary are complete aircraft which have been hypothetically scaled down in size and weight to take advantage of system weight changes and improvements in engine performance while performing the specified S-3A baseline mission. Weight growth factor in relation to changes in payload or fixed weight in an existing aircraft is not applicable. The weight growth factor in optimized S-3A aircraft Configurations 1 and 2 was established at 3.60. The impact of 270 Vdc avionic power supplies on DGTOW is shown in Table 1-8.

1.2.2.6 Life Cycle Cost

Aircraft weight savings, fuel savings, and avionic power supply reliability improvements obtained through the application of 270 Vdc system technology have been previously identified in units peculiar to each, i.e., fixed weight pounds, pounds per mission, mean time between failures (MTBF) hours, etc. Comparison of unlike units is not possible except through a common parameter in which all units can be mutually expressed. The parameter selected for final evaluation of the impact of 270 Vdc acionic power supplies was LCC.

Projected cost savings of an optimized S-3A aircraft and an optimized V-STOL type aircraft making use of this technology, along with improved avionic cooling methods are graphically displayed in Figure 1-3. The baselines in Figure 1-3 represent the LCC of the two aircraft with present technology subsystems. Incremental cost savings per aircraft identified in terms of airframe, fuel usage, power supply maintenance and repair, and subsystems equipment are shown for three configurations analyzed.

Values used in this LCC analysis are given in Table 1-9.

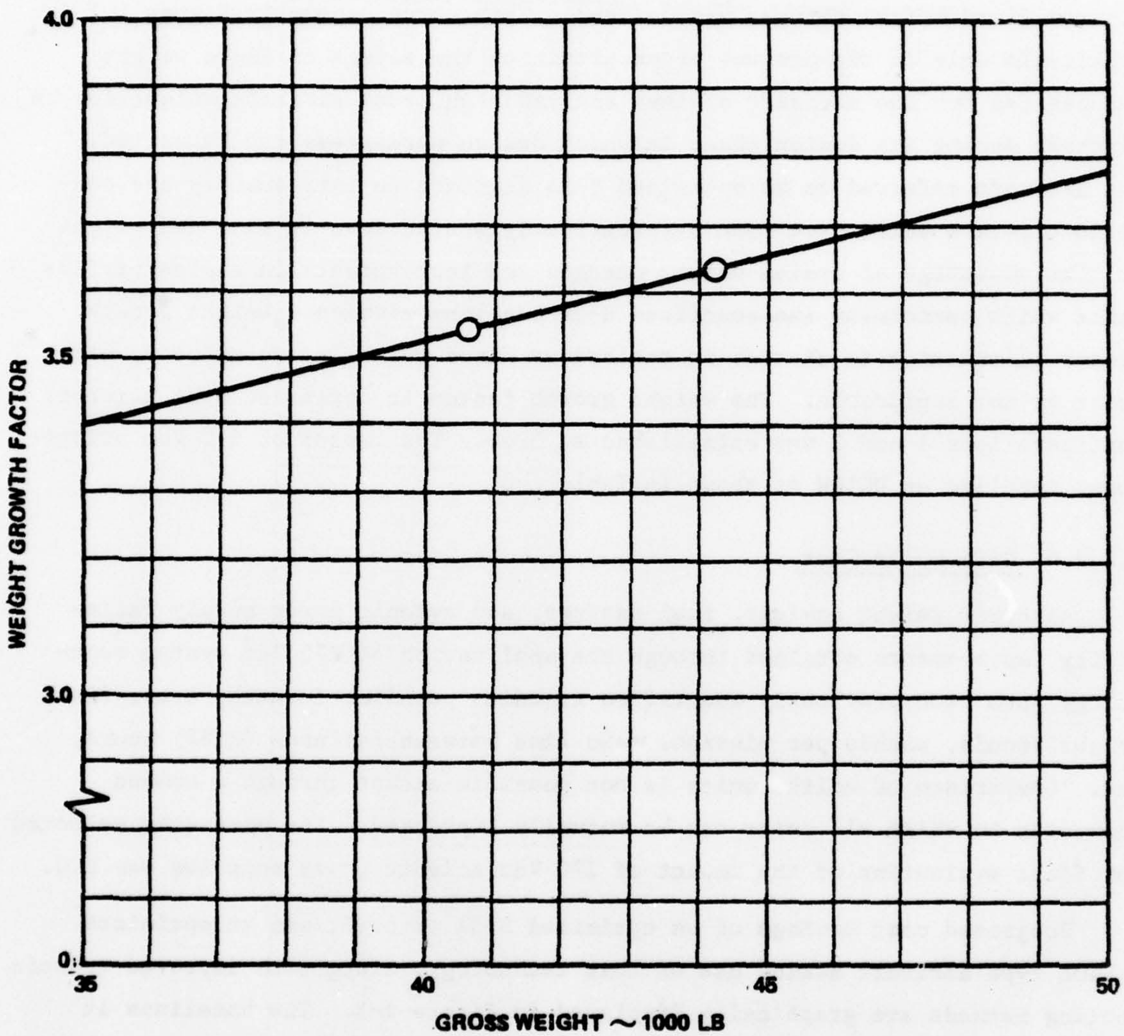


Figure 1-2. Weight Growth Factor versus Gross Weight

TABLE 1-8. OPTIMIZED S-3A DESIGN GTOW WEIGHT SUMMARY

Aircraft Configuration	Aircraft ΔWeights - Lb					
Description	Avionics ΔWt	Electric System ΔWt	ECS ΔWt	Total ΔWt	Growth Factor	DGTOW ΔWt
Baseline Production S-3A 400 Hz Power Supplies Air Cycle ECS Air Cold Plate Cooling	0	0	0	0	-	0
Optimized S-3A (Configuration 1) 270 Vdc Power Supplies Air Cycle ECS Air Cold Plate Cooling	-268.1	-75.1	-56.2	-399.4	3.60	-1437.8
Optimized S-3A (Configuration 2) 270 Vdc Power Supplies Vapor Cycle ECS Vapor Expansion Cold Plate Cooling	-273.2	+106.2	-318.0	-485.0	3.60	-1746.0

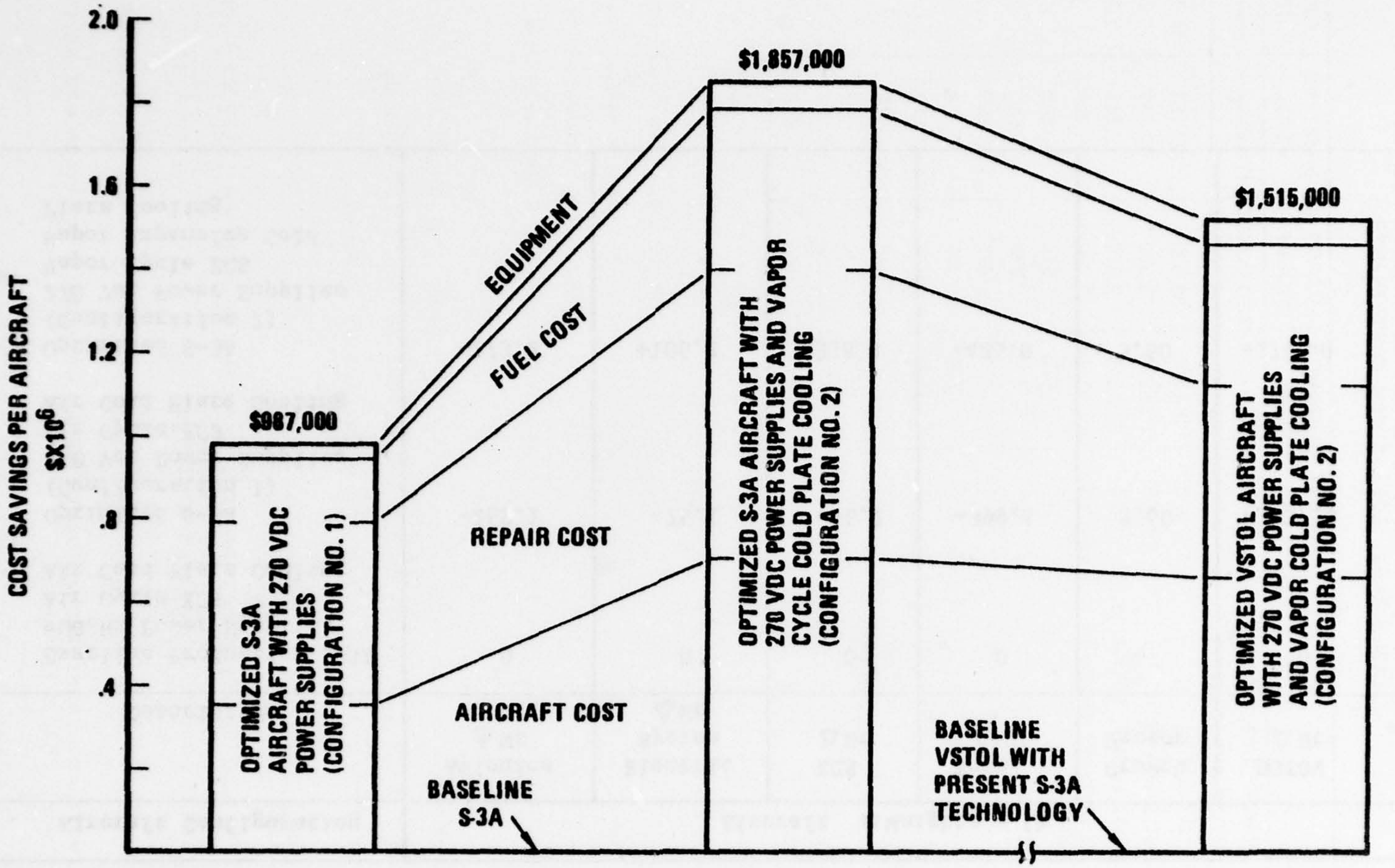


Figure 1-3. Aircraft Life Cycle Cost Savings From Application of New Technology

TABLE 1-9. LIFE CYCLE COST INPUTS

		PRESENT S-3A	270 VDC PS	VAPOR COOLING	BASELINE VSTOL	OPT. VSTOL
C_a	POWER SUPPLY COST ($)	← ASSUMED CONSTANT →				
C_ℓ	ELECT. SYS. COST ($)	← ASSUMED CONSTANT →				
C_e	ECS COST ($)	167,913	154,305	90,639	137,781	74,358
H_ℓ	A/C LIFE (HRS)	13,500	13,500	13,500	10,800	10,800
C_m	COST/MAINT. ACTION ($)	2,215	2,215	2,215	2,215	2,215
F	GROWTH FACTOR	3.6	3.6	3.6	3.8	3.8
W_a	PWR. SUPPLY LBS.	847	579	574	696	475
W_e	ECS LBS.	691	635	373	567	306
W_f	FUEL LBS.	1,060	990	653	796	516
C_p	$/LB. STOW	300	300	300	352	352
F_f	FUEL FRACTION	0.27	0.27	0.27	0.19	0.19
C_f	$/LB. FUEL	0.15	0.15	0.15	0.15	0.15
H_f	HRS./FLIGHT	6.57	6.57	6.57	3.8	3.8
MTBF	MTBMA X 4	69	141	345	84	421
W_ℓ	ELECT. SYS. LBS.	831	756	938	682	769

1.2.3 Power Supply Analysis Results

The results of the analysis performed on the seven selected subsystems showed a reduction in power supply power dissipation of 2386.4 watts and a weight reduction of 162.6 pounds. Parametrically extending these values across the remaining subsystems gave a total decrease of 4008 watts and 268.1 pounds.

Similar improvements were found in power supply MTBF and MTBMA. The MTBF increased from 276 hours to 563 and 69 to 141 hours for MTBMA. As a result, maintenance support costs are dramatically reduced.

1.3 CONCLUSIONS

The following conclusions resulted from the 270 Vdc vs 115/200V, 400 Hz primary aircraft avionic subsystem analysis:

1. Power supply efficiency can be increased an average of 14 percent.
2. Electrical power requirements on an S-3A avionic suite can be reduced by more than 4000 watts.

3. Power supply weight can be reduced by more than 250 pounds.

4. MTBF and MTBMA can be increased 278 and 72 hours respectively.

5. ECS system weight can be reduced 53 pounds.

6. Aircraft electrical power system weight can be reduced 75.1 pounds.

7. Aircraft GTOW can be reduced 1437.8 pounds

8. Cost of ownership or LCC can be reduced to more than $1,800,000 per aircraft.

In general, the 270 Vdc primary aircraft electrical system will have dramatic positive effects on reliability, maintainability, and aircraft support costs. Higher reliability means fewer maintenance actions, standardization of power supply designs reduces initial design costs and spares support costs, and lighter, smaller ECS and electrical generator systems reduce aircraft weight and fuel consumption.

SECTION 2

ANALYSES

The 270 Vdc impact study was restricted to the evaluation of the impact of 270 Vdc primary aircraft power and avionic power supplies used to develop secondary avionic dc power as opposed to standard 115/200V, 400 Hz aircraft power currently used on naval aircraft. It included secondary impacts on the ECS, electrical system, engine performance, mission performance and LCC. The analysis was performed in the order shown in Figure 2-1.

The baseline aircraft selected for this analysis is Lot VII Production S-3A, Navy Serial No. 160567, as of 15 November 1976, for which comprehensive weight and performance data was assembled. It is identified in Table 2-1 as BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D." The mission shown corresponds to a specification mission for which the S-3A was originally designed and is maintained as a constant in this analysis. The avionics suite in the baseline S-3A is air cold plate-cooled by 80°F cabin air and by ambient (103°F maximum) forced air. Cooling of the cabin air is provided by an air cycle environmental control system (ECS) obtaining its input from engine compressor bleed air and auxiliary power unit (APU) air.

2.1 AVIONIC POWER SUPPLY ANALYSIS

Avionic subsystem power supplies were analyzed to determine the effect of replacing the standard 115/200V, 400 Hz/28 Vdc primary aircraft power sources with a 270 Vdc primary power source. The power supply study first determined the input/output characteristics of existing power supplies (input voltage/power, power supply dissipation/efficiency, output voltage/power, weight, and volume). Once the parameters had been established new switched mode regulators were designed to satisfy the output load requirements previously established and to comply with MIL-STD-704. (An interesting note is that

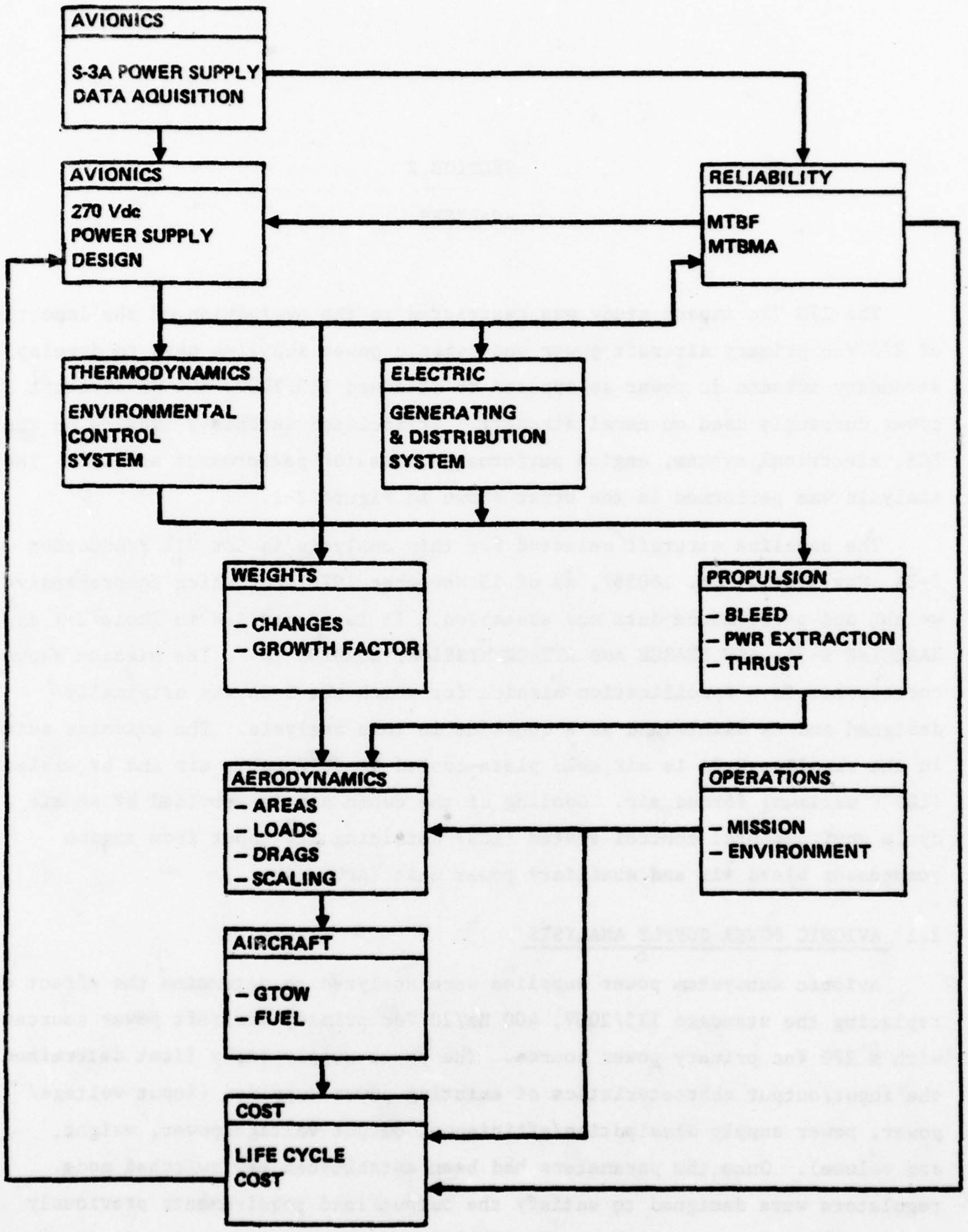
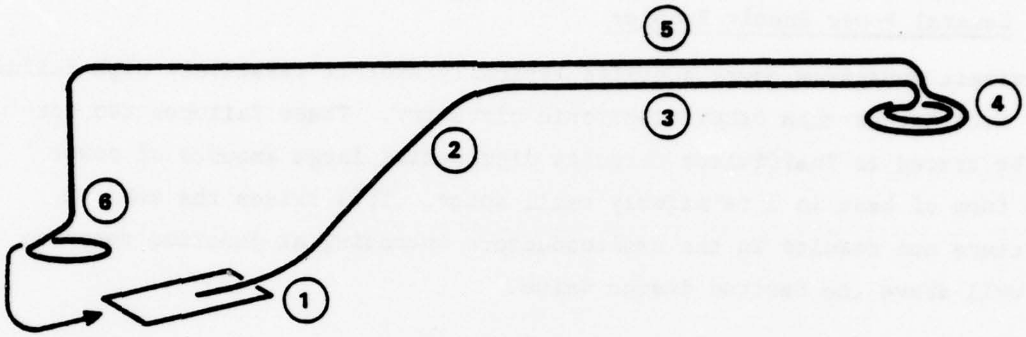


Figure 2-1. Analysis Flow Diagram

TABLE 2-1. BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D" (SPECIFICATION AIRCRAFT)



Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-Up & Takeoff	44,286	-	0	0.08	460	-
2. Climb	43,826	220	0	0.32	1149	99
3. Cruise Out at Optimum Altitude	42,677	355	36,100	0.73	1292	257
4. Loiter on Station	41,388	370	38,000 to 40,000	4.5	7624	0
5. Cruise Back at Optimum Altitude	33,760	356	40,000	1.02	1464	356
6. Reserve Loiter	32,296	160	0	0.33	496	-
5% Initial Fuel Reserve	31,800	-	-	-	657	-

Totals:	Mission Time (Items 2 through 5)	6.57 Hr
	Mission Fuel (Items 1 through 5)	11,989 Lb
	Fuel Load	13,142 Lb
	Radius of Operation	356 NM

many of the 115/200V, 400 Hz power supplies analyzed were not required to comply with MIL-STD-704, therefore the switched mode regulators provide more capability than the existing design.)

2.1.1 General Power Supply Problem

Avionic subsystem power supplies typically exhibit relatively high failure rates, much higher than other electronic circuitry. These failures can normally be traced to inefficient circuits dissipating large amounts of power in the form of heat in a relatively small space. This raises the ambient temperature and results in the semiconductors operating at junction temperatures well above the desired design value.

2.1.2 Aircraft Impact

To determine the full impact on the S-3A aircraft of operating the avionics systems power supplies from 270 Vdc source in lieu of a 115/200V 400 Hz source, the following items were analyzed:

- Power supply weight
- Power supply volume
- Power supply efficiency
- Power supply reliability
- Aircraft electric system weight
- Environmental control system (ECS) capacity and weight
- Aircraft propulsion performance
- Aircraft mission fuel usage
- Aircraft design gross takeoff weight (DGTOW)
- Aircraft cost-of-ownership

2.1.3 Solutions Offered by 270 Vdc Power System

With the advent of 270 Vdc primary aircraft power, the highly efficient switched mode regulator power supply becomes a viable alternative to the standard series pass regulators currently in common use. They offer higher efficiencies, lower weight, and increased reliability. In addition, they also offer more opportunity for commonality and standardization.

Higher efficiency reduces the load on aircraft primary power and ECS systems, reduces avionic hardware weight, GTOW, and fuel consumption, improves mission performance by increasing flight time, and significantly reduces LCC.

2.1.4 Analysis Methodology

The power supply study began by selecting a statistically acceptable representative group of avionic subsystems for detailed analysis, the results of which would be used to parametrically evaluate the remaining avionic subsystems. (A statistically valid sample would be that number of subsystems whose total power consumption equals or is greater than root-mean-square (RMS) value of the total avionic system's power consumption.)

Power flow diagrams of the selected subsystems were then constructed, accounting for the total power consumed by each in terms of power supply inputs, outputs, losses, and user electronic circuit consumption.

Each subsystem was analyzed to identify discrete power supplies within the selected subsystems whose design, characteristics, and complexity vary widely, such as:

- Transformer input, series pass regulated
- Off-line rectifier input, series switched mode regulated
- Voltage multipliers
- Single and multiple voltage outputs
- Very low voltage (0-7V)
- Low voltage (7.01-15V)

- Intermediate voltage (15.01-85.0V)
- High voltage (85.01-500V)
- Very high voltage (1000-10,000V)
- Air cooled
- Fluid immersed
- Modular
- Distributed

Weights, volumes, power input, power output, efficiency, regulation, and EMI control characteristics of these selected power supplies were determined by laboratory measurement and/or manufacturer's data, where available.

These data, with the design criteria outlined below, were used by a power supply design subcontractor to establish the weights, volumes, efficiencies, and reliability predictions of power supplies operating from a nominal 270 Vdc source with the following characteristics:

- Output voltage characteristics: Normal operating voltage 250 to 280. Transient voltage envelope and rated performance within limits A and C of Figure 2-2.
- Maximum ripple: 12 volts peak to peak with frequency components within the limits of Figure 6, MIL-STD-704B.
- Cooling Configuration 1: Forced air at the rate of 6 lbs/min/kW power dissipated. Maximum inlet temperature 80°F. Exhaust temperature 120°F.
- Cooling Configuration 2: Conduction to infinite cold plate with interface maintained at 5°C (41°F).
- EMI control: Input/Output in accordance with MIL-STD-461A, Notice 3.
- Unit reliability: Improvement Goal - 8:1 per CNO (OR) WSL-40

These data were then applied to the power supplies in each of the selected subsystems, and remaining subsystems to determine the individual and collective impacts on the avionic system. The results of this effort were then used to determine the impact on other aircraft systems and mission performance.

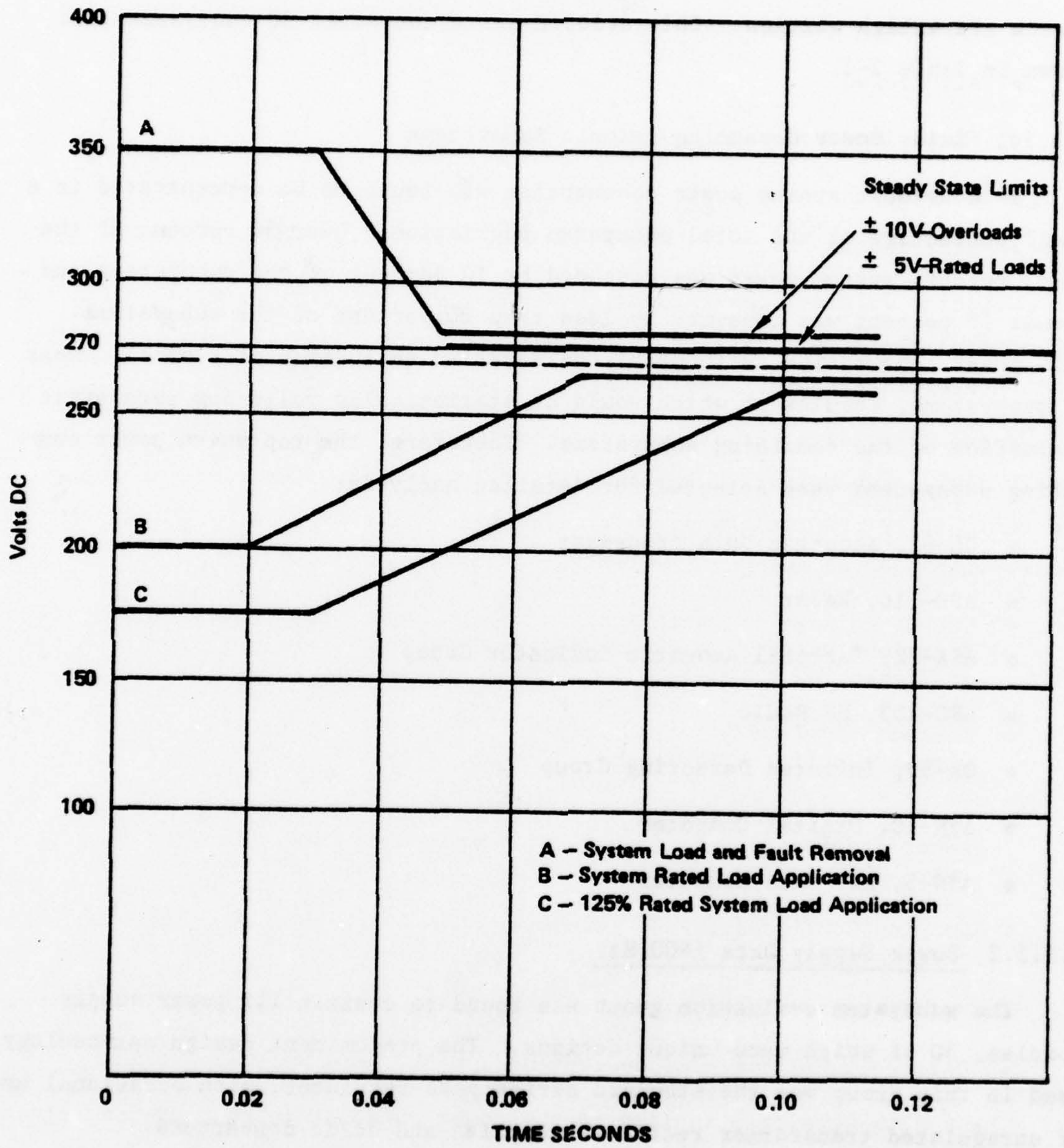


Figure 2-2. Power Supply Input Characteristics

2.1.5 S-3A Avionic Subsystems

The avionic subsystem chosen for this analysis was configured for an ASW Search and Attack mission. This avionic suite contained 38 subsystems, as shown in Table 2-2.

2.1.5.1 Major Power Consuming Avionic Subsystems

S-3A avionic system power consumption was found to be concentrated in a small percentage of the total subsystem population. Over 50 percent of the total avionic system power was consumed by 10 percent of the subsystems and almost 75 percent was consumed by less than 20 percent of the subsystems. This power consumption ratio permitted detailed evaluation of a small number of subsystems, results of which would be statistically valid for parametric evaluation of the remaining subsystems. Therefore, the top seven power consuming subsystems were selected for detailed analysis:

- OL-82, Acoustic Data Processor
- APS-116, Radar
- ASA-82, Tactical Acoustic Indicator Group
- ARC-153, HF Radio
- OR-89, Infrared Detecting Group
- AYK-10, Digital Computer
- AYN-5, Air Data Computer

2.1.5.2 Power Supply Data (400 Hz)

The subsystem evaluation group was found to contain 111 power supply modules, 60 of which were unique designs. The predominant design methodology used in this group was the standard series pass regulator, with occasional use of unregulated transformer rectifier supplies and dc/dc converters.

Each power supply was empirically evaluated to determine:

- Input voltage
- Input power (volt-amperes and watts)

TABLE 2-2. POWER CONSUMPTION, S-3A AVIONIC SUBSYSTEMS

System	Nom	VA Input	System	Nom	VA Input
1. OL-82	ADP	4688 VA	20. ASN-107	AITRS	200 VA
2. APS-116	Radar	4300 VA	21. CV-2830	D/A Conv	200 VA
3. ASA-82	TDS	4200 VA	22. ASQ-81	MAD Set	190 VA
4. ARC-153	HF Radio	3680 VA	23. ARA-63	INS Landg	170 VA
5. OR-89	FLIR	2675 VA	24. APN-200	NAV Radar	150 VA
6. AYK-10	GPDC	2500 VA	25. ARS-2	SONO Rcvr	120 VA
7. AYN-5A	AACS	1720 VA	26. APX-72	IFF XPNAR	120 VA
8. ASW-33	AFCS	315 VA +400 WDC	27. ASA-65	MAD Comp	110 VA
			28. OA-8770	VID Rcdr	100 VA +6 WDC
9. ARC-156	UHF Radio	700 VA			
10. ASN-92	CAINS	700 VA	29. TSEC/KY-28 8	KEY GEN	87 VA
11. OK-248	CC/ICS	685 VA	30. TSEC/KY-40	KEY GEN	87 VA
12. OU-79	R/S Conv.	630 VA	31. ASA-84	INS	85 VA
13. ASQ-147	INCOS	555 VA	32. CV-2881	MAD	85 VA
14. ALR-47	ESM	549 VA	33. RD-348	DMTU	75 VA
15. ARN-84	TACAN	400 VA	34. APN-201	RAAWS	72 VA
16. OD-59	FDIS	392 VA	35. APN-202	BEACON	70 VA
17. APR-76	SRX	265 VA	36. ARN-83	LF ADF	61 VA
18. ASH-27A	ATR	285 VA	37. ASW-25	ACLS	60 VA
19. APX-76	IFF	200 VA	38. ARA-50	UHF/DF	50 VA

- Output voltage(s)
- Output power
- Percentage of regulation
- Output current
- Power dissipated
- Overall power supply efficiency
- Unit weight
- Unit volume.

The results of this evaluation are found in Tables 2-3 through 2-9. Where avionic hardware was not available for physical measurement, the latest published data was used.

The APS-116 hardware was not available for measurement, and published data lacked the detail and continuity necessary for this study. Numerous contracts with the GFE vendor did not improve this situation very much; therefore, the APS-116 was treated separately.

2.1.5.3 Power Supply Classification

The power supplies under study were grouped together according to their output voltage and power characteristics. Five voltage categories ranging from 0 to 10 kV and five power ranges from 0 to 1500 watts (Table 2-10) were used in the classification process. The results of this classification process are shown in Tables 2-11 through 2-17. (Multiple output power supplies may be rated in one or more categories.)

TABLE 2-3a

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: CV-2882A/AYS, Signal Data Converter (WRA 1) **P/N:** 1022401

POWER SUPPLY SRA: Power Inverter +5/+38 (A31) **P/N:** 1023782

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA [1][2]	INPUT WATTS [1][2][3]	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS [1]	DISSIP. WATTS [1][4]
85/180 400 Hz	3	590	542.5	115	7.3	+5 +38 ±19 ±16	57.2 0.26 3.8 2.9	10 10 10 10	286 10 70.5 48.5	127.5

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 415.0 127.5

OUTPUT TO: CP-1140A (WRA5), SG-962A (WRA3), and CV-2882A (WRA1) Circuitry **EFFICIENCY:** 0.7650

POWER SUPPLY SRA: Positive Regulator +12 (A33) **P/N:** 1026390

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
±14.7/18 dc	-	-	9.0	13	0.42	+12.0	0.52	10	6.2	2.8

INPUT FROM: 1023782 **TOTAL:** 6.2 2.8

OUTPUT TO: CV-2882A (WRA1) Circuitry **EFFICIENCY:** 0.6889

POWER SUPPLY SRA: Negative Regulator -12V (A34) **P/N:** 1026389

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
±14.7/18 dc	-	-	18.5	13	0.40	-12.0 -5.0	0.32 1.8	10	3.8 9.0	5.7

INPUT FROM: 1023782 **TOTAL:** 12.8 5.7

OUTPUT TO: CV-2882A (WRA1) Circuitry **EFFICIENCY:** 0.6908

[1] Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

[2] Sum of all phases

[3] DC watts where applicable

[4] $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-3b

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: CV-2882A, Signal Data Converter (WRA2) **P/N:** 1022401

POWER SUPPLY SRA: Power Inverter **P/N:** 1023782

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1 ⚠2 ⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
85/180 400 Hz	3	590	542.5	115	7.3	+5 +38 ±19 ±16	57.2 0.26 3.8 2.9	10 10 10 10	286 10 70.5 48.5	127.5

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 415.0 127.5
OUTPUT TO: CP-1140A (WRA5), SG-962A (WRA3), and CV-2882A (WRA1) Circuitry **EFFICIENCY:** 0.7650

POWER SUPPLY SRA: Positive Regulator +12 (A33) **P/N:** 1026390

±14.7/18 dc	-	-	9.0	13	0.42	+12	0.52	10	6.2	2.8

INPUT FROM: 1023782 **TOTAL:** 6.2 2.8
OUTPUT TO: CV-2882A (WRA2) Circuitry **EFFICIENCY:** 0.6889

POWER SUPPLY SRA: Negative Regulator -12V (A34) **P/N:** 1026389

±14.7/18 dc	-	-	18.5	13	0.40	-12 -5	0.32 1.8	10	3.8 9.0	5.7

INPUT FROM: 1023782 **TOTAL:** 12.8 5.7
OUTPUT TO: CV-2882A (WRA2) Circuitry **EFFICIENCY:** 0.6908

⚠1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

⚠2 Sum of all phases
⚠3 DC watts where applicable
⚠4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-3c

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: SG-962A, Signal Generator Spectrum Analyzer (WRA 3) **P/N:** 1022403

POWER SUPPLY SRA: Power Inverter +5V (A38) **P/N:** 1023771

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1 △2 △3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
85/180 400 Hz	3	619	568	115	7.4	+5	77.2	10	386	182

INPUT FROM:
OUTPUT TO:

TOTAL: 386 182
EFFICIENCY: 0.6796

POWER SUPPLY SRA: Keep Alive Power Supply (A40) **P/N:** 1023358

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
85/180 400 Hz	3	133	122	14	1.22	+5 +12 -6	10.5 0.5 2.4	10	52.7 6 14.5	48.8

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: SG-962 Circuitry

TOTAL: 73.2 48.8
EFFICIENCY: 0.6000

POWER SUPPLY SRA: Positive Regulator +15V (A41) **P/N:** 1026390

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
±17.4/21.3 dc	-	-	20.5	13	0.42	+15	0.93	10	14	6.5

INPUT FROM: CV-2882A (WRA1)
OUTPUT TO: SG-962A Circuitry

TOTAL: 14 6.5
EFFICIENCY: 0.6829

POWER SUPPLY SRA: Negative Regulator -15V (A42) **P/N:** 1026389

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
17.4/21.3 dc	-	-	23	13	0.40	-15	0.99	10	15	8

INPUT FROM: CV-2887A (WRA1)
OUTPUT TO: SG-962A Circuitry

TOTAL: 15 8
EFFICIENCY: 0.6522

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-3d

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: CV-2883A Converter, Spectrum Analyzer (WRA4) **P/N:** 1022404

POWER SUPPLY SRA: Power Inverter +5V (A38) **P/N:** 1023771

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1 ⚠2 ⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
85/180 400 Hz	3	613	562	96	6.18	+5	78.8	10	394	168

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 394 168
OUTPUT TO: CV-2883A Circuitry **EFFICIENCY:** 0.7011

POWER SUPPLY SRA: Positive Regulator +15V (A41) **P/N:** 1026390

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
±17.4/21.3 dc	-	-	20.5	13	0.42	+15	0.93	10	14	6.5

INPUT FROM: CV-2882A (WRA2) **TOTAL:** 14 6.5
OUTPUT TO: CV-2883A (WRA4) Circuitry **EFFICIENCY:** 0.6829

POWER SUPPLY SRA: Negative Regulator -15V (A42) **P/N:** 1026389

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
±17.4/21.3 dc	-	-	23	13	0.40	-15	0.99	10	15	8

INPUT FROM: CV-2882A (WRA2) **TOTAL:** 15 8
OUTPUT TO: CV-2883A (WRA4) Circuitry **EFFICIENCY:** 0.6522

POWER SUPPLY SRA: Keep Alive Power Supply (A40) **P/N:** 1023358

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
85/180 400 Hz	3	133	122	14	1.22	+5 +12 -6	10.5 0.5 2.4	10	52.7 6 14.5	48.8

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 73.2 48.8
OUTPUT TO: SG-962 Circuitry **EFFICIENCY:** 0.6000

⚠1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

⚠2 Sum of all phases
⚠3 DC watts where applicable
⚠4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-3e

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: CP-1140A, Computer, Sonar Data (WRA5) **P/N:** 1022409

POWER SUPPLY SRA: Power Inverter +5V (A42) **P/N:** 1023771

INPUT VOLTAGE MIN/MAX	PHASES	[1] [2] INPUT VA	[1] [2] [3] INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	[1] OUTPUT WATTS	[1] [4] DISSIP. WATTS
85/180 400 Hz	3	582	534	115	7.4	+5	78	10	390	144

INPUT FROM: Aircraft Power
OUTPUT TO: CP-1140A Circuitry

TOTAL: 390 144
EFFICIENCY: 0.7303

POWER SUPPLY SRA: Positive Regulator +17, +20V (A44) **P/N:** 1026390

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
$\pm$17.4/21.3 dc	-	-	27	13	0.42	+17 +20	0.9 0.45	10	6.6 9.0	11.4

INPUT FROM: CV-2882A (WRA1)
OUTPUT TO: CP-1140A Circuitry

TOTAL: 15.6 11.4
EFFICIENCY: 0.5778

POWER SUPPLY SRA: Negative Regulator -10V (A45) **P/N:** 1026389

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
$\pm$14.7/18 dc	-	-	21.0	13	0.40	-10	0.77	10	13.0	8.0

INPUT FROM: CV-2992A (WRA1)
OUTPUT TO: CP-1140A Circuitry

TOTAL: 13.0 8.0
EFFICIENCY: 0.6191

[1] Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

[2] Sum of all phases

[3] DC watts where applicable

[4] $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-3f

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: CP-1140A Computer, Sonar Data (WRA6) **P/N:** 1022409

POWER SUPPLY SRA: Power Inverter +5V (A42) **P/N:** 1023771

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA (1)(2)	INPUT WATTS (1)(2)(3)	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS (1)	DISSIP WATTS (1)(4)
85/180 400 Hz	3	582	534	115	7.4	+5	78	10	390	144

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 390 144
OUTPUT TO: CP-1140A Circuitry **EFFICIENCY:** 0.7303

POWER SUPPLY SRA: Positive Regulator +17, +20V (A44) **P/N:** 1026390

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP WATTS
$\pm$17.4/21.3 dc	-	-	27	13	0.42	+17 +20	0.9 0.45	10	6.6 9.0	11.4

INPUT FROM: Power Inverter 1023782 (WRA2) **TOTAL:** 15.6 11.4
OUTPUT TO: CP-1140A (WRA6) **EFFICIENCY:** 0.5778

POWER SUPPLY SRA: Negative Regulator -10V (A45) **P/N:** 1026389

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP WATTS
$\pm$14.7/18 dc	-	-	21.0	13	0.40	-10	0.77	10	13.0	8.0

INPUT FROM: CV-2882A (WRA2) **TOTAL:** 13.0 8.0
OUTPUT TO: CP-1140A Circuitry **EFFICIENCY:** 0.6191

(1) Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

(2) Sum of all phases
(3) DC watts where applicable
(4) $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-3g

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Acoustic Data Processor, OL-82A/AYS

WRA: PP-6671 Power Supply, Drum (WRA 11) **P/N:** 621600-4

POWER SUPPLY SRA: PS No. 1 **P/N:**

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1⚠2⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
85/160	3	396	341	700	24.35	+20 Vdc +12 Vdc + 5 Vdc - 5 Vdc 38 Vac			9.42 25.0 6.68 106.0 1.4	136.5

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 204.5 136.5
OUTPUT TO: Drum WRA **EFFICIENCY:** 0.5997

POWER SUPPLY SRA: PS No. 2 **P/N:**

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
85/160	3	396	341	700	24.35	+20 Vdc +12 Vdc + 5 Vdc - 5 Vdc 38 Vac			9.42 25.0 6.68 106.0 1.4	136.5

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 204.5 136.5
OUTPUT TO: Drum WRA **EFFICIENCY:** 0.5997

⚠1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.
⚠2 Sum of all phases
⚠3 DC watts where applicable
⚠4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

EMI SUPPRESSION

☒ MIL-STD-461A NOTICE:

☐ OTHER:

TABLE 2-4a

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: APS-116 Radar

WRA: T-1203, Transmitter **P/N:** 719214

POWER SUPPLY SRA: Low Voltage Power Supply (3A1A7) **P/N:** 715335-1

INPUT VOLTAGE MIN/MAX	PHASES	[1] [2] INPUT VA	[1] [2] [3] INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	[1] OUTPUT WATTS	[1] [4] DISSIP. WATTS
115/200 400 Hz	3	270.1	231.3	33.7	2.57	-16.1 + 6.9 +54.5 -54.5 -22.5 - 2.9	0.05 15.0 0.01 0.01 2.5 2.0		0.805 103.5 0.545 0.545 56.25 5.80	63.86

INPUT FROM: Aircraft Power **TOTAL:** 167.45

OUTPUT TO: T-1203 Circuitry **EFFICIENCY:** 0.7240

POWER SUPPLY SRA: HV Power Supply **P/N:** 719214

115/200 400 Hz	3	2893	2606	124.3	18.32	9200	0.252	Unregulated	2319	287

INPUT FROM: Aircraft Power **TOTAL:** 2319 287

OUTPUT TO: T-1203 Circuitry **EFFICIENCY:** 0.8898

POWER SUPPLY SRA: TWT Ion Pump P/S **P/N:** 715383-1

115 400 Hz	1	4.0	2.7			3 kv	0.0001	Unregulated	0.3	2.4

INPUT FROM: Aircraft Power **TOTAL:** 0.3 2.4

OUTPUT TO: Ion Pump **EFFICIENCY:** 0.1111

[1] Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

[2] Sum of all phases

[3] DC watts where applicable

[4] $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-4b

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: APS-116 Radar

WRA: PP-6633, Power Supply/Programmer — **P/N:** 718364

POWER SUPPLY SRA: Unregulated Power Supply (A-13) — **P/N:** 718371

INPUT VOLTAGE MIN/MAX	PHASES	(1) (2) INPUT VA	(1) (2) (3) INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	(1) OUTPUT WATTS	(1) (4) DISSIP. WATTS
115/200 400 Hz	3	508	447	224	5.40			Unregulated	389.5	57.5

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: 718403, 718374, External System

TOTAL: 389.5 57.5
EFFICIENCY: 0.8714

POWER SUPPLY SRA: Low Voltage Regulator (A-9) / Heat Sink Voltage Regulator (A-14) — **P/N:** 718374/718403

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
±27 dc ±10 dc ±15 dc ±14 dc +36 dc	-	-	192	78	1.125				140.5	51.5

INPUT FROM: 718371
OUTPUT TO: PP-6633 Interval Circuitry

TOTAL: 140.5 51.5
EFFICIENCY: 0.7318

POWER SUPPLY SRA: Servo Amp P.S. (A-15) — **P/N:** 718372

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
115/200 400 Hz	3	546	480	224	5.9	±60 ac 26 ac	7.0 A 0.388		420 7.5	52.5

INPUT FROM: Aircraft Power
OUTPUT TO: A-16 and A-17

TOTAL: 427.5 52.5
EFFICIENCY: 0.8906

(1) Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

(2) Sum of all phases

(3) DC watts where applicable

(4) $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-4c

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: APS-116 Radar

WRA: CV-2852, Signal Data Converter Storer — **P/N:** 711451-9

POWER SUPPLY SRA: Transformer (6T1) — **P/N:** 711843

INPUT VOLTAGE MIN/MAX	PHASES	Δ1 Δ2 INPUT VA	Δ1 Δ2 Δ3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	Δ1 OUTPUT WATTS	Δ1 Δ4 DISSIP. WATTS
115/200 400 Hz	3	188	162		2.81	11/40 ac 115 ac	2.452 0.7626		64 87.7	10.3

INPUT FROM: Aircraft Power — **TOTAL:** 151.7 — 10.3
OUTPUT TO: 711657 and 711824 — **EFFICIENCY:** 0.9364

POWER SUPPLY SRA: ±15 Vdc, -85 Vdc Power Supply — **P/N:** 711658

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
11/40 400 Hz	1	76	64		1.37	±15 dc ±21 dc -85 dc			21 5 9	29

INPUT FROM: 711843 — **TOTAL:** 35 — 29
OUTPUT TO: 711657 and CV-2852 Circuitry — **EFFICIENCY:** 0.5469

POWER SUPPLY SRA: +28 Vdc, +40 Vdc and Filament P/S (A4) — **P/N:** 711824

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
115	1	103	87.7		1.12	+28 +40 + 6.3 - 5			35 5 7 3	37.7

INPUT FROM: 711843 — **TOTAL:** 50 — 37.7
OUTPUT TO: 711657 and CV-2852 Circuitry — **EFFICIENCY:** 0.5701

POWER SUPPLY SRA: High Voltage Power Supply (6PS2) — **P/N:** 711657

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
-85 +15 +28			1.5 2.0 35.0		2.52				23	15.5

INPUT FROM: 711658 and 711824 — **TOTAL:** 23 — 15.5
OUTPUT TO: CV-2852 Circuitry — **EFFICIENCY:** 0.5974

Δ1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

Δ2 Sum of all phases

Δ3 DC watts where applicable

Δ4 $WATTS_{IN}$ - $WATTS_{OUT}$ = $WATTS_{DISS.}$ (AVERAGE)

TABLE 2-4d

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: APS-116 Radar

WRA: C-8788, Radar Set Control — P/N: 71146-5

POWER SUPPLY SRA: Power Supply (7 psi) — P/N: 711741

INPUT VOLTAGE MIN/MAX	PHASES	1 2 INPUT VA	1 2 3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	1 OUTPUT WATTS	1 4 DISSIP. WATTS
115/200 400 Hz	3	199	167			+5	21.6		108	59

INPUT FROM: Aircraft Power
OUTPUT TO: C-8788

TOTAL: 108 59
EFFICIENCY: 0.6467

1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

2 Sum of all phases
3 DC watts where applicable
4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-5a

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: Pilot Display, IP-1051/ASA-82 — **P/N:** 231502-924

POWER SUPPLY SRA: Transformer — **P/N:** 226686-000

INPUT VOLTAGE MIN/MAX	PHASES	(1) (2) INPUT VA	(1) (2) (3) INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	(1) OUTPUT WATTS	(1) (4) DISSIP. WATTS
115/200	3	629	437	39.4	5.5	20/105 ac 21 ac 10/107 ac 57 ac	0.722 2.52 1.02 4.65	None	43.3 52.9 56.3 265.3	19.2

INPUT FROM: Aircraft Power (Left Buss)
OUTPUT TO: 232011-924, 232477-924, 232478-924, 232555-924

TOTAL: 417.8 19.2
EFFICIENCY: 0.9561

POWER SUPPLY SRA: VR1 — **P/N:** 232555-924

4.5/89	3	306.9	265.3	14.7	0.780	-27	6.289	10	169.8	95.5

INPUT FROM: 226292-000
OUTPUT TO: IP-1051 Circuitry

TOTAL: 169.8 95.5
EFFICIENCY: 0.6400

POWER SUPPLY SRA: VR2 — **P/N:** 232477-924

16.7/33.4 16.0/32.0	3	60.9	52.9	14.7	0.700	+15 -15	0.947	10	14.2 14.2	12.25 12.25

INPUT FROM: 226686-000
OUTPUT TO: IP-1051 Circuitry

TOTAL: 28.4 24.5
EFFICIENCY: 0.5369

POWER SUPPLY SRA: VR3 — **P/N:** 232478-924

8.0/15.9 83.8/0.167	3	64.7	56.3	14.7	0.750	+5 -85	1.2 0.42	10	3.8 22.6	29.9

INPUT FROM: 226686-000
OUTPUT TO: IP-1051 Circuitry

TOTAL: 26.4 29.9
EFFICIENCY: 0.4689

(1) Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

(2) Sum of all phases
(3) DC watts where applicable
(4) $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-5a (Continued)

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: Pilot Display, IP-1051/ASA-82 P/N: 231502-924

POWER SUPPLY SRA: VR4 P/N: 232011-924

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA (1) (2)	INPUT WATTS (1)(2)(3)	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS (1)	DISSIP. WATTS (1) (4)
82.3/164 15.2/30.4	3	49.7	43.3	14.7	0.650	+85	0.357	10	30.3	13.0

INPUT FROM: 226686-000 TOTAL: 30.3 13.0
OUTPUT TO: IP-1051 Circuitry EFFICIENCY: 0.6998

POWER SUPPLY SRA: High Voltage Power Supply P/N: 226179-000

+85 dc +15 dc -15 dc			22.1 0.9 0.4	16	2.250	10 kV (580 dc)	0.001	-	10.1	13.3

INPUT FROM: VR2 and VR4 TOTAL: 10.1 13.3
OUTPUT TO: IP-1051 Circuitry EFFICIENCY: 0.4316

TABLE 2-5b

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: AUX Readout Unit, IP-1052/ASA-82 **P/N:** 231560-924

POWER SUPPLY SRA: Transformer **P/N:** 226292-000

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1 △2 △3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
115/200 400	3	306	263	41.95	5.75	33/50 ac 17.6 ac 10/80 ac 13/77 ac 30 ac	0.971 3.046 0.769 1.589 1.527	None	40.3 53.6 34.6 71.5 45.8	17.2

INPUT FROM: Aircraft Power **TOTAL:** 245.8 17.2
OUTPUT TO: 232482-913, 232483-917, 232484-909, 232485-909 and 232551-924 **EFFICIENCY:** 0.9346

POWER SUPPLY SRA: VR5 **P/N:** 232554-924

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
24/48	3	53.5	45.8	14.7	0.468	-22	1.332	10	29.3	16.5

INPUT FROM: 226292-000 **TOTAL:** 29.3 16.5
OUTPUT TO: IP-1052 Circuitry **EFFICIENCY:** 0.6397

POWER SUPPLY SRA: VR4 **P/N:** 232485-909

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
60/120 10/20	3 3	82.8	71.5	14.7	0.750	+85 -27	0.26 1.44	10 Unregulated	22.1 39	10.4

INPUT FROM: **TOTAL:** 61.1 10.4
OUTPUT TO: **EFFICIENCY:** 0.8545

POWER SUPPLY SRA: VR3 **P/N:** 232484-909

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
7.2/14.0 62/124	3 3	40.5	34.6	14.7	0.625	+5.0 -85.0	1.6 0.054	10	8.0 4.6	22

INPUT FROM: 226292-000 **TOTAL:** 12.6
OUTPUT TO: IP-1052 Circuitry **EFFICIENCY:** 0.3642

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-5b (Continued)

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: AUX Readout Unit, IP-1052/ASA-82 **P/N:** 231560-924

POWER SUPPLY SRA: VR2 **P/N:** 232483-917

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1 ⚠2 ⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
13.8/27 13.8/27	3 3	62.5	53.6	14.7	0.690	+15 -15	2.0 1.0	10	19.1 9.6	24.9

INPUT FROM: 226292-000
OUTPUT TO: IP-1052 Circuitry

TOTAL: 28.7 24.9
EFFICIENCY: 0.5355

POWER SUPPLY SRA: VR1 **P/N:** 232482-913

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
25.7/51.4 39.0/78.0	3	47.1	40.3	14.7	0.718	+50 -28	0.37 0.254	10	18.5 7.1	14.7

INPUT FROM: 226292-000
OUTPUT TO: IP-1052 Circuitry

TOTAL: 25.6 14.7
EFFICIENCY: 0.6352

POWER SUPPLY SRA: High Voltage Power Supply **P/N:** 226179-000

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+85 vdc +15 vdc -15 vdc	-	-	22.1 0.9 0.4	16	2.25	10 Kv (580 vdc)	0.001 (NEGL)	-	10.1	13.3

INPUT FROM:
OUTPUT TO:

TOTAL: 10.1 13.3
EFFICIENCY: 0.4316

TABLE 2-5c

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: Co-Pilot Display, IP-1053/ASA-82 **P/N:** 231503-924

POWER SUPPLY SRA: VR1 **P/N:** 232577-924

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1 △2 △3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
44.5/89.0 25.6/51.3	3	351	310	14.7	1.062	-85 -29.5	0.06 7.56	10	5.1 223	81.9

INPUT FROM: 226685-000 **TOTAL:** 228.1 81.9
OUTPUT TO: IP-1053 Circuitry **EFFICIENCY:** 0.7358

POWER SUPPLY SRA: VR2 **P/N:** 232479-924

16.7/33.4 16.0/31.8	3	110	95.3	14.7	0.812	+15 -15	1.89 1.51	10	28.3 22.7	44.3

INPUT FROM: 226685-000 **TOTAL:** 51.0 44.3
OUTPUT TO: IP-1053 Circuitry **EFFICIENCY:** 0.5352

POWER SUPPLY SRA: VR3 **P/N:** 232480-924

8/15.9 838/167	3	43	37.8	14.7	0.800	+5 -85	1.58 0.075	10	7.9 6.4	23.5

INPUT FROM: 226685-000 **TOTAL:** 14.3 23.5
OUTPUT TO: IP-1053 Circuitry **EFFICIENCY:** 0.3783

POWER SUPPLY SRA: VR4 **P/N:** 232481-924

82.3/164 15.2/30.4	3	94	81.3	14.7	0.812	+85		10	54.8	26.5

INPUT FROM: 226685-000 **TOTAL:** 54.8 26.5
OUTPUT TO: IP-1053 Circuitry **EFFICIENCY:** 0.6741

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-5c (Continued)

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: Copilot Display, IP-1053/ASA-82 **P/N:** 231503-924

POWER SUPPLY SRA: High Voltage Power Supply **P/N:** 226179-000

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1 ⚠2 ⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
+85 dc +15 dc -15 dc			22.1 0.9 0.4	16	2.250	10 kV (580 dc)	0.001 (NEGL)		10.1	13.3

INPUT FROM: 232479-924 and 232481-924
OUTPUT TO: IP-1053 Circuitry

TOTAL: 10.1 13.3
EFFICIENCY: 0.4316

POWER SUPPLY SRA: Transformer **P/N:** 226685-000

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
115/200	3	632	552	41.95	5.75	20/105 vac 20.5/21.5 vac 10.2/107 vac 33/57 vac			81.3 95.3 37.8 310.0	27.6

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: 232577-924, 232480-924, 232479-924, and 232481-924

TOTAL: 524.4 27.6
EFFICIENCY: 0.9500

TABLE 2-5d
S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: TACCO/SENSO Displays, IP-1054/ASA-82 **P/N:** 231504-924

POWER SUPPLY SRA: VR1 **P/N:** 232577-924

INPUT VOLTAGE MIN/MAX	PHASES	(1) (2) INPUT VA	(1)(2)(3) INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	(1) OUTPUT WATTS	(1) (4) DISSIP. WATTS
44.5/89 25.6/51	3	373	324.4	14.7	1.062	-85 -29.5	0.064 7.895	10	5.4 232.9	86.1

INPUT FROM: 226685-000 **TOTAL:** 238.3 86.1
OUTPUT TO: IP-1054 Circuitry **EFFICIENCY:** 0.7346

POWER SUPPLY SRA: VR2 **P/N:** 232479-924

16.7/33.4 16.0/31.8	3	114	99.6	14.7	0.812	+15 -15	1.973 1.58	10	29.6 23.7	46.3

INPUT FROM: 226685-000 **TOTAL:** 53.3 46.3
OUTPUT TO: IP-1054 Circuitry **EFFICIENCY:** 0.5351

POWER SUPPLY SRA: VR3 **P/N:** 232480-924

8/15.9 83.8/167	3	45	39.5	14.7	0.300	+5 -85	1.66 0.079	10	8.3 6.7	24.5

INPUT FROM: 226685-000 **TOTAL:** 15 24.5
OUTPUT TO: IP-1054 Circuitry **EFFICIENCY:** 0.3798

POWER SUPPLY SRA: VR4 **P/N:** 232481-924

82.3/164 15.2/30.4	3	98	84.9	14.7	0.812	+85	0.853	10	57.2	27.7

INPUT FROM: 226685-000 **TOTAL:** 57.2 27.7
OUTPUT TO: IP-1054 Circuitry **EFFICIENCY:** 0.6737

(1) Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

(2) Sum of all phases
(3) DC watts where applicable
(4) $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-5d (Continued)

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: TACCO/SENSO Displays, IP-1054/ASA-82 — **P/N:** 231504-924

POWER SUPPLY SRA: High Voltage Power Supply — **P/N:** 226179-000

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1 ⚠2 ⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
+85Vdc +15Vdc -15Vdc			22.1 0.9 0.4	16	2.250	10 kV (580Vdc)	0.001 (NEGL)	- -	10.1	13.3

INPUT FROM: 232479-924 and 232481-924
OUTPUT TO: IP-1054 Circuitry

TOTAL: 10.1 13.3
EFFICIENCY: 0.4316

POWER SUPPLY SRA: Transformer — **P/N:** 226685-000

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
115/200	3	661	577	41.95	5.75	33/57 vac 10.2/107 vac 20.5/21.5 vac 20/105 vac	7.21 0.67 4.74 1.36		324.4 39.5 99.6 84.9	28.6

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: 232577-924, 232480-924, 232479-924, and 232481-924

TOTAL: 584.4 28.6
EFFICIENCY: 0.9504

TABLE 2-5e
S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Tactical Acoustic Indicator Group, ASA-82

WRA: DGU, CV-2806/ASA-82 — **P/N:** 231507-924

POWER SUPPLY SRA: VR1, VR4, VR7, and VR10 — **P/N:** 231909-924

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1△2△3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
13.6/17	3	85	74.1	12.4	0.562	+15 dc	2.547	10	38.2	35.9

INPUT FROM: Transformer on CV-2806 Main Frame — **TOTAL:** 38.2 35.9
OUTPUT TO: CV-2806 Circuitry — **EFFICIENCY:** 0.5155

POWER SUPPLY SRA: VR2, VR5, VR8, and VR11 — **P/N:** 231911-925

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
8.6/17.2	3	16	13.7	12.4	0.750	+5	1.42	10	7.1	6.6

INPUT FROM: Transformer on CV-2806 Main Frame — **TOTAL:** 7.1 6.6
OUTPUT TO: CV-2806 Circuitry — **EFFICIENCY:** 0.5182

POWER SUPPLY SRA: VR3, VR6, VR9, and VR12 — **P/N:** 231910-924

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
15.2/30.0	3	77	67.5	12.4	0.530	-15	1.98	10	29.7	37.8

INPUT FROM: Transformer on CV-2806 Main Frame — **TOTAL:** 29.7 37.8
OUTPUT TO: CV-2806 Circuitry — **EFFICIENCY:** 0.4400

POWER SUPPLY SRA: Transformer — **P/N:** 226245-000

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
115/200	3	777	672	25.5	3.9	20.0 ac 11.3 ac 15.0 ac	13.5 4.85 19.76	.	621.2	50.8

INPUT FROM: Aircraft Power — **TOTAL:** 621.2 50.8
OUTPUT TO: VR1 through VR12 — **EFFICIENCY:** 0.9244

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-6
S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: HF Radio (ARC-153A)

WRA: RCVR/XMTR RT-1016 **P/N:** 792-6390-008

POWER SUPPLY SRA: Power Supply, A7 **P/N:** 606-9378-001

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1△2△3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
26/30 Vdc	—	—	87	—	—	+28	0.82	—	23	0
				44.3	2.3	+20	0.32	±0.5	6.4	
						+15	1.11	±0.7	16.7	50.2
						-15	0.61	±0.7	9.2	
						+ 5	0.9	±0.5	4.5	

INPUT FROM: AM-6384A
OUTPUT TO: RT-1016

TOTAL: 36.8 50.2
EFFICIENCY: 0.4230

WRA: RF Amplifier AM-6384A **P/N:** 792-6422-005

POWER SUPPLY SRA: Power Supply, A02 **P/N:** 606-9058-004

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1△2△3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
90/160	3	2563	2230	282	39.3	+23	100 MA	±4V	2.3	830
						+28	6.2	±4V	173.6	
						+18	450 MA	±50 MV	8.1	
						+ 5	1.75	±300 MV	8.75	
						-18	330 MA	±50 MV	5.28	
						+2000	0.49	±260V	980	
						+500	225 MA	±50V	112.5	
						+375	130 MA	±20	48.5	
						+160	15 MA	+0 -10	2.6	
						-80	30 MA	±2	2.4	
						+325	Negligible			
						13.5 ac	1.5	±1.4	20.2	
						6.3 ac	5.7	±1.35	36	

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: RT-1016 and AM-6384 Circuitry

TOTAL: 1400.23 830
EFFICIENCY: 0.6279

WRA: CU-1985 Antenna Coupler **P/N:** 792-6239-002

POWER SUPPLY SRA: Power Supply, A4 **P/N:** 790-2799

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1△2△3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
90/160	3	48	43	66.5	2.5	+10.7	0.09	5	1	20
						-11.3	0.09	5	1	
						+ 4.9	0.61	5	3	
						+32.4	0.56	13	18	
		+28Vdc	0.56	-	-	-	-	-	-	0.56

INPUT FROM: Aircraft Power
OUTPUT TO: CU-1985 Circuitry

TOTAL: 23 20.36
EFFICIENCY: 0.5280

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases

△3 DC watts where applicable

△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-7a

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Infrared Detecting Group, OR-89A/AA

WRA: PP-7197, Video Converter Power Supply **P/N:** 708002-7

POWER SUPPLY SRA: Video Regulator (A1) **P/N:** 768689

INPUT VOLTAGE MIN/MAX	PHASES	1 2 INPUT VA	1 2 4 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	1 OUTPUT WATTS	1 4 DISSIP. WATTS
93/188 400 Hz	3	101	87	190.6	1.33	+15 dc	3.4	10	51	36

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO:
TOTAL: 51 36
EFFICIENCY: 0.5862

POWER SUPPLY SRA: Video Regulator (A2) **P/N:** 768689

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188 400 Hz	3	101	87	190.6	1.33	+15 dc	3.4	10	51	36

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO:
TOTAL: 51 36
EFFICIENCY: 0.5862

POWER SUPPLY SRA: Video Regulator (A3) **P/N:** 768689

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188 400 Hz	3	101	87	190.6	1.33	+15 dc	3.4	10	51	36

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO:
TOTAL: 51 36
EFFICIENCY: 0.5862

POWER SUPPLY SRA: Video Regulator (A4) **P/N:** 768689

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188 400 Hz	3	101	87	190.6	1.33	+15 dc	3.4	10	51	36

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO:
TOTAL: 51 36
EFFICIENCY: 0.5862

1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

2 Sum of all phases

3 DC watts where applicable

4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-7a (Continued)

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Infrared Detecting Group, OR-89A/AA

WRA: PP-7197, Video Converter Power Supply — **P/N:** 708002-7

POWER SUPPLY SRA: Scan Drive (A7) — **P/N:** 708896

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA [1] [2]	INPUT WATTS [1] [2] [3]	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS [1]	DISSIP. WATTS [1] [4]
93/188 400 Hz	3	512	440		0.7	115 ac			20 290	130

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: IP-1069

TOTAL: 310 130
EFFICIENCY: 0.7046

POWER SUPPLY SRA: $\pm$15V Reg (A6) — **P/N:** 768682

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188 400 Hz	3	101	87	190.6	1.33	$\pm$15	3.4	10	51	36

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO:

TOTAL: 51 36
EFFICIENCY: 0.5862

POWER SUPPLY SRA: TEC Power (A15) — **P/N:** 708742

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188 400 Hz	3	1523	1371		10.78	101 ac	13.03		1316	55

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO: IP-1069

TOTAL: 1316 55
EFFICIENCY: 0.9599

POWER SUPPLY SRA: Camera Regulator (A5) — **P/N:** 768681

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188 400 Hz	3	138	119	190.6	1.33	20	5.95		80	39

INPUT FROM: Aircraft 400 Hz Power
OUTPUT TO:

TOTAL: 80 39
EFFICIENCY: 0.6723

TABLE 2-7b

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Infrared Detecting Group, OR-89A/AA

WRA: IP 1069/IP 1214, IR Viewer — **P/N:** 708001-7

POWER SUPPLY SRA: — **P/N:** 744545

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA △1 △2	INPUT WATTS △1 △2 △3	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS △1	DISSIP. WATTS △1 △4
115 ac			20		1.32	+39 dc		±1.0	10.4	5.6

INPUT FROM: 708002-7 — **TOTAL:** 10.4 5.6
OUTPUT TO: — **EFFICIENCY:** 0.5200

POWER SUPPLY SRA: Bias Pack (A1A1A5) — **P/N:** 788345

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
-15	-	-	6		1.32	-5	0.9	±5	4.5	1.5

INPUT FROM: C-8759 — **TOTAL:** 4.5 1.5
OUTPUT TO: — **EFFICIENCY:** 0.7500

POWER SUPPLY SRA: SCR Bridge — **P/N:**

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
101 ac			1316		1.32	140	9.21	-	1290	26

INPUT FROM: PP-7197 — **TOTAL:** 1290 26
OUTPUT TO: — **EFFICIENCY:** 0.9802

POWER SUPPLY SRA: 3 Kv P/S (PSI) — **P/N:** 715376

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
93/188	3	27	23		1.32	3 Kv	0.0017		5.0	18

INPUT FROM: Aircraft 400 Hz Power — **TOTAL:** 5.0 18
OUTPUT TO: — **EFFICIENCY:** 0.2174

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc. or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-7c

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Infrared Detecting Group, OR-89A/AA

WRA: C-8759, IR Control Converter **P/N:** 708003-6

POWER SUPPLY SRA: 26V XFMR Assy **P/N:** 708279

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1 △2 △3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
88/180	3	10	6		0.8	26 ac	0.192	None	5	1

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 5 1
OUTPUT TO: **EFFICIENCY:** 0.8333

POWER SUPPLY SRA: ±15 Vdc Module **P/N:** 768682

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
88/180	3	100	87		1.33	+15 -15		±5	32 19	36

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 51 36
OUTPUT TO: **EFFICIENCY:** 0.5862

POWER SUPPLY SRA: 5 Vdc Regulator **P/N:** 708277

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
88/180	3	122	105		1.33	+5	9.6		48	57

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 48 57
OUTPUT TO: **EFFICIENCY:** 0.4571

POWER SUPPLY SRA: 30 Vdc Bridge **P/N:** 810262

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
88/180	3	64	56		3.6	+30 -30	0.567 0.933		17 28	11

INPUT FROM: Aircraft 400 Hz Power **TOTAL:** 45 11
OUTPUT TO: **EFFICIENCY:** 0.8036

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-8a

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Computer, Digital AYK-10A(V)

WRA: Power Supply No. 1, PP-6679 (Left Side) **P/N:** 7131700-06

INPUT VOLTAGE MIN/MAX	PHASES	△1 △2 INPUT VA	△1 △2 △3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	△1 OUTPUT WATTS	△1 △4 DISSIP. WATTS
58/160	3	1121	979	1008	31.7	+100 +100 +100	2.16 2.47 3.93	±3 ±1 ±1	216 247 393	123

INPUT FROM: Aircraft Power
OUTPUT TO: PP-6675, PP-6676, and PP-6677

TOTAL: 856 123
EFFICIENCY: 0.8744

WRA: Converter, CP PP-6675 (Left Side) **P/N:** 7511300-00

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+100 ±1 dc	-	-	247	138	6.32	+5.7 +5.0 +14.0 +28.0	0.24 34.24 0.06 0.05	3 2 10 10	1.4 171.2 0.9 1.5	72

INPUT FROM: PP-6679 (SW. Reg. Type A)
OUTPUT TO: MX-9088/AYK-10A(V)

TOTAL: 175 72
EFFICIENCY: 0.7085

WRA: Converter, Memory PP-6676 (Left Side) **P/N:** 7131775-01/7131840-01

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+100 ±3 dc	-	-	216	101	4.52	±10 ±6 ±5 +20 +28	0.39 5.0 17.01 0.15 0.11	5 5 5 5 5	7.8 60.0 85.0 3.0 3.0	57.2

INPUT FROM: PP-6679 (SW. Reg. Type B)
OUTPUT TO: MU-577A/AYK-10A(V)

TOTAL: 158.8 57.2
EFFICIENCY: 0.7352

WRA: Converter, Input/Output PP-6677 (Left Side) **P/N:** 7511200-01

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+100 ±1 dc	-	-	393	149	6.81	-10 -5.7 -5.3 +5 +6	0.39 0.35 1.75 52.0 1.65	10 3 5 2 2	3.9 2.0 9.3 260 10.0	107.8

INPUT FROM: PP-6679 (SW. Reg. Type A)
OUTPUT TO: MX-9088/AYK-10A(V)

TOTAL: 285.2 107.8
EFFICIENCY: 0.7257

△1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

△2 Sum of all phases
△3 DC watts where applicable
△4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-8b

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: Computer, Digital AYK-10A(V)

WRA: Power Supply No. 2, PP-6678 (Right Side) **P/N:** 7131700-07

INPUT VOLTAGE MIN/MAX	PHASES	⚠1 ⚠2 INPUT VA	⚠1⚠2⚠3 INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	⚠1 OUTPUT WATTS	⚠1 ⚠4 DISSIP. WATTS
58/160 L-N 400 Hz	3	1026	893	1008	31.7	+100 +100 +100	2.08 2.48 3.21	±3 ±1 ±1	208 248 321	116

INPUT FROM: Aircraft Power
OUTPUT TO: PP-6675, PP-6676, and PP-6677

TOTAL: 777 116
EFFICIENCY: 0.8701

WRA: Converter, CP PP-6675 (Right Side) **P/N:** 7511300-00

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+100 ±1 dc	-	-	248	138	6.32	+5.7 +5.0 +14.0 +28.0	0.24 34.7 0.06 0.05	3 2 10 10	1.36 173.4 0.9 1.4	70.9

INPUT FROM: PP-6678 (SW. Reg. Type A)
OUTPUT TO: MX-9088/AYK-10A(V)

TOTAL: 177.1 70.9
EFFICIENCY: 0.7141

WRA: Converter, Memory PP-6676 (Right Side) **P/N:** 7131775-01, 7131840-01

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+100 ±3 dc	-	-	208	101	4.52	±10 ±6 +5 +20 +28	0.39 4.75 16.8 0.15 0.08	5 5 5 5 5	7.8 57.0 85.1 3.0 2.2	52.9

INPUT FROM: PP-6678 (SW. Reg. Type B)
OUTPUT TO: MU-577A/AYK-10A(V)

TOTAL: 155.1 52.9
EFFICIENCY: 0.7457

WRA: Converter, Input/Output PP-6677 (Right Side) **P/N:** 7511200-01

INPUT VOLTAGE MIN/MAX	PHASES	INPUT VA	INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	OUTPUT WATTS	DISSIP. WATTS
+100 ±1 dc	-	-	321	149	6.81	-10 -5.7 -5.3 +5 +6	0.39 0.35 1.75 41.5 1.16	10 3 5 2 2	3.9 2.0 9.3 207.5 7.0	91.3

INPUT FROM: PP-6678 (SW. Reg. Type A)
OUTPUT TO: MX-9088/AYK-10A(V)

TOTAL: 229.7 91.3
EFFICIENCY: 0.7156

⚠1 Average at nominal input voltage (115 volts phase to neutral, 28 Vdc, or other power supply). At nominal input frequency (400 Hz), and at average output demand.

⚠2 Sum of all phases
⚠3 DC watts where applicable
⚠4 $WATTS_{IN} - WATTS_{OUT} = WATTS_{DISS.}$ (AVERAGE)

TABLE 2-9

S-3A WEAPONS SYSTEM AVIONICS POWER SUPPLY ANALYSIS

WEAPONS SUBSYSTEM: AYN-5 (AACS) Air Data Computer

WRA: CP-1077A **P/N:** 19820000-13

POWER SUPPLY SRA: PS-1 and 2 **P/N:** 2786869-1

INPUT VOLTAGE MIN/MAX	PHASES	[1] [2] INPUT VA	[1] [2] [3] INPUT WATTS	VOL IN^3	WT LB	OUTPUT VOLTAGES	OUTPUT CURRENTS NOMINAL	PERCENT VOLTAGE REGULATION	[1] OUTPUT WATTS	[1] [4] DISSIP. WATTS
80/180	3	102.2	91.98	112.8	4.56	-24	0.032	Unregulated	0.9	22.38
						+20	0.100	3	2.0	
						-20	0.150	3	3.0	
						+15	0.525	5	7.9	
						-15	0.61	5	9.2	
						+12	0.36	5	4.3	
						+10	0.012	3	0.2	
						+5	7.60	3	40.9	
						-15	0.8		1.2	
								Total:	69.6	22.38
80/180	3	19.8	17.82			5.7 ac	0.2	-	1.14	0.78
						26.0 ac	0.2	-	5.2	
						12.8 ac	0.36	-	4.6	
						14.0 ac	0.44	-	6.1	
								Total:	17.04	0.78

INPUT FROM: Aircraft Power
OUTPUT TO: CP-1077A Circuitry

TOTAL: 86.64 23.16
EFFICIENCY: DC = 0.7567
AC = 0.9562

TABLE 2-10. POWER SUPPLY CLASS.FICATION

Category	Voltage	Power				
		1	2	3	4	5
A. Very Low Voltage	0-7	0-10	10.1-50	50.1-200	200 -500	
B. Low Voltage	7.01-15	0-10	10.1-50	50.1-200		
C. Intermediate Voltage	15.01-85	0-10	10.1-50	50.1-200	200.1-500	
D. High Voltage	85.01-500	0-10				500-1500
E. Very High Voltage	1K-10K	0-10				500-1500

TABLE 2-11. OL-82A/AYS, RADIO COMPUTING-TRACKING GROUP (ADP)

ITEM NO.	PART NUMBER	DESCRIPTION	TRACKING					REMARKS
			A	B	C	D	E	
1	1023782	Power Inverter	X	X	X			TACCO
2	1023771	Power Inverter	X					TACCO
3	1023771	Power Inverter	X					TACCO
4	1/2-	Drum Power Supply	X	X	X			TACCO
5	1023782	Power Inverter	X	X	X			SENSO
6	1023771	Power Inverter	X					SENSO
7	1023771	Power Inverter	X					SENSO
8	1/2	Drum Power Supply	X	X				SENSO
9	1026390	+12 V dc Regulator		X				TACCO
10	1026339	-12/-5 V dc Regulator	X	X				TACCO
11	1026390	+15 V dc Regulator		X				TACCO
12	1026389	-15V dc Regulator		X				TACCO
13	1023358	Keep Alive Power Supply	X	X				TACCO
14	1026390	+20/+17 V dc Regulator		X	X			TACCO
15	1026389	-10 V dc Regulator		X				TACCO
16	1026390	+12 V dc Regulator		X				SENSO
17	1026389	-15/-5 V dc Regulator	X	X				SENSO
18	1026390	+15 V dc Regulator		X				SENSO
19	1026389	-15 V dc Regulator		X				SENSO
20	1023358	Keep Alive Power Supply	X	X				SENSO
21	1026390	+20/+17 V dc Regulator			X			SENSO
22	1026389	-10 V dc Regulator		X				SENSO

TABLE 2-12. APS-116 POWER SUPPLY CLASSIFICATION

ITEM NO.	PART NUMBER	DESCRIPTION	CATEGORY A	B	C	D	E	REMARKS
1	718364	Power Supply PP-6633						
1A	718403	Low Voltage Regulator						
1B	718374	Low Voltage Heat Sink Regulator						
1B	718732	Servo-Amp Power Supply			X			
1C	718371	Unregulated Power Supply						
2		High Voltage P.S.					X	
3	715335	Xmitter Low Voltage P.S.	X	X	X			
4	715383	TWT Ion Pump P.S.					X	
5	711741	Radar Set Control Power Supply	X					
7	711658	6PS1 Power Supply		X	X			
8	711657	6PS2 HV Power Supply				X	X	
9	711824	Low Voltage P.S.	X		X			

TABLE 2-13. ASA-82 POWER SUPPLY CLASSIFICATION

Item No.	Part Number	Description	Category A	B	C	D	E	Remarks
1	232555-924	Voltage Regulator #1			X			Pilot Display
2	232477-924	Voltage Regulator #2		X				Pilot Display
3	232478-924	Voltage Regulator #3	X		X			Pilot Display
4	232011-924	Voltage Regulator #4			X			Pilot Display
5	226179-000	High Voltage Power Supply					X	Pilot Display
6	232482-913	Voltage Regulator #1			X			ARU
7	232483-917	Voltage Regulator #2		X				ARU
8	232484-909	Voltage Regulator #3	X		X			ARU
9	232485-909	Voltage Regulator #4			X			ARU
10	232554-924	Voltage Regulator #5			X			ARU
11	226179-000	High Voltage Power Supply					X	ARU
12	232577-924	Voltage Regulator #1			X			SENSO Display
13	232479-924	Voltage Regulator #2		X				SENSO Display
14	232480-924	Voltage Regulator #3	X		X			SENSO Display
15	232481-924	Voltage Regulator #4			X			SENSO Display
16	226179-000	High Voltage Power Supply					X	SENSO Display
17	231909-909	+15 Volts Regulator		X				DGU
18	231911-925	+5 Volts Regulator	X					DGU
19	231910-924	-15 Volts Regulator		X				DGU
20	231909-909	+15 Volts Regulator						DGU
21	231911-925	+5 Volts Regulator	X	X				DGU
22	231910-924	-15 Volts Regulator		X				DGU
23	231909-909	+15 Volts Regulator		X				DGU
24	231911-925	+5 Volts Regulator	X					DGU
25	231910-924	-15 Volts Regulator		X				DGU
26	231909-909	+15 Volts Regulator						DGU
27	231911-925	+5 Volts Regulator	X	X				DGU
28	231910-924	-15 Volts Regulator		X				DGU

TABLE 2-13. ASA-82 POWER SUPPLY CLASSIFICATION (Continued)

Item No.	Part Number	Description	Category A	B	C	D	E	Remarks
29	232577-924	Voltage Regulator #1			X			Copilot Display
30	232479-924	Voltage Regulator #2		X				Copilot Display
31	232480-924	Voltage Regulator #3	X		X			Copilot Display
32	232481-924	Voltage Regulator #4		X				Copilot Display
33	226179-000	High Voltage Power Supply					X	Copilot Display
34	232577-924	Voltage Regulator #1			X			TACCO Display
35	232479-924	Voltage Regulator #2		X				TACCO Display
36	232480-924	Voltage Regulator #3	X		X			TACCO Display
37	232481-924	Voltage Regulator #4			X			TACCO Display
38	226179-000	High Voltage Power Supply					X	TACCO Display

TABLE 2-14. ARC-153A

ITEM NO.	PART NUMBER	DESCRIPTION	CATEGORY					REMARKS
			A	B	C	D	E	
1	606-9058	RF Amplifier Power Supply						
1A	797-3597	HV Rectifier Assembly					X	
1B	797-3594	18 V dc Regulator			X			
1C	797-3596	5/80 V dc Regulator	X		X			
1D	797-3598	Screen Regulator				X		
2	606-9378	Power Supply HF R/T	X	X	X			
3	790-2799	Antenna Coupler PS	X	X	X			

TABLE 2-15. OR-89A/AA, POWER SUPPLY CLASSIFICATION

ITEM NO.	PART NUMBER	DESCRIPTION	CATEGORY					REMARKS
			A	B	C	D	E	
1	768689	Video Regulator		X				
2	768689	Video Regulator		X				
3	768689	Video Regulator		X				
4	768689	Video Regulator		X				
5	768681	Camera Regulator			X			
6	768682	±15V Regulator		X				
7	768682	±15V Regulator		X				
8	810262	±30V Regulator			X			
9	708277	+5V Regulator						
10	715376	3 kV Power Supply	X				X	
11	708896	Scan Drive			X	X		
12	708742	TEC Power Supply				X		
13	744545				X			
14	788345	Bias Pack	X					
15		SCR Bridge				X		
16	708279				X			

TABLE 2-16. AYK-10A POWER SUPPLY CLASSIFICATION

Item No.	Part Number	Description	Category A	B	C	D	E	Remarks
1	7131700-06	Power Supply #1						
1A	7131720	Switching/Regulator Type A				X		
1B	7131720	Switching/Regulator Type A				X		
1C	7131740	Switching/Regulator Type B				X		
2	7511300	CP dc to dc Converter	X	X	X			
3	7131775 and 7131840	Memory dc to dc Converter	X	X	X			
4	7511200	I/O dc to dc Converter	X	X				
5	7131700-07	Power Supply #2						
5A	7131720	Switching-Regulator Type A				X		
5B	7131720	Switching-Regulator Type A				X		
5C	7131740	Switching-Regulator Type B				X		
6	7511300	CP dc to dc Converter	X	X	X			
7	7131775 and 7131840	Memory dc to dc Converter	X	X	X			
8	7511200	I/O dc to dc Converter	X	X				

TABLE 2-17. AYN-5 POWER SUPPLY CLASSIFICATION

Item No.	Part Number	Description	Category A	B	C	D	E	Remarks
1	1978869	Power Supply PS1	X	X	X			
2	1978869	Power Supply PS2	X	X	X			

2.1.5.4 Subsystem Power Flow

Subsystem power flow and power accounting was accomplished by constructing plower flow diagrams on each subsystem. The diagrams show power supply input voltage and power, output voltages and power, and the amount of power dissipated by each power supply module.

2.1.5.4.1 OL-82A/AYS, Radio Computing-Tracking Group (ADP)

The ADP is comprised of seven WRA's containing internal power supply circuitry:

WRA 1	CV-2882A - Signal Data Converter, PN 1022401
WRA 2	CV-2882A - Signal Data Converter, PN 1022401
WRA 3	SG-962A - Signal Generator Spectrum Analyzer, PN 1022403
WRA 4	CV-2883A - Converter Spectrum Analyzer, PN 1022404
WRA 5	CP-1140A - Computer, Sonar Data, PN 1022409
WRA 6	CP-1140A - Computer, Sonar Data, PN 1022409
WRA 11	PP-6671A - Drum Power Supply, PN 6201600-4

Power flow and accounting is shown in Figure 2-3. A detailed examination of each unique WRA revealed even more commonality at the SRA level. Four of the seven WRA's contain +5V power inverters (PN 1023771) in the 380-400 watt range, CY-2882 contains a +5V output from its power inverter in the 300 watt range, and PP-6671 has two +5V supplies at 56 watts each. Five WRA's contain positive and negative series pass regulators (PN 1026390 and 1026389, respectively) which operate off of the power inverters located in CV-2882. A careful examination of these circuits shows they supply a relatively narrow range of voltage (+12 to +20V and -5 to -15V) but with large amounts of power being dissipated in their series pass elements, particularly at lower voltages. In addition, the tandum power supply approach of the latter further reduces the total efficiency of the ADP power supply system resulting in an overall efficiency of 67.96 percent.

The ADP power supply commonality factor $\frac{(N_T + 1) - N_U}{N_T}$ is 0.75, where N_T is the total number of power supply circuits and N_U is the number of unique circuits.

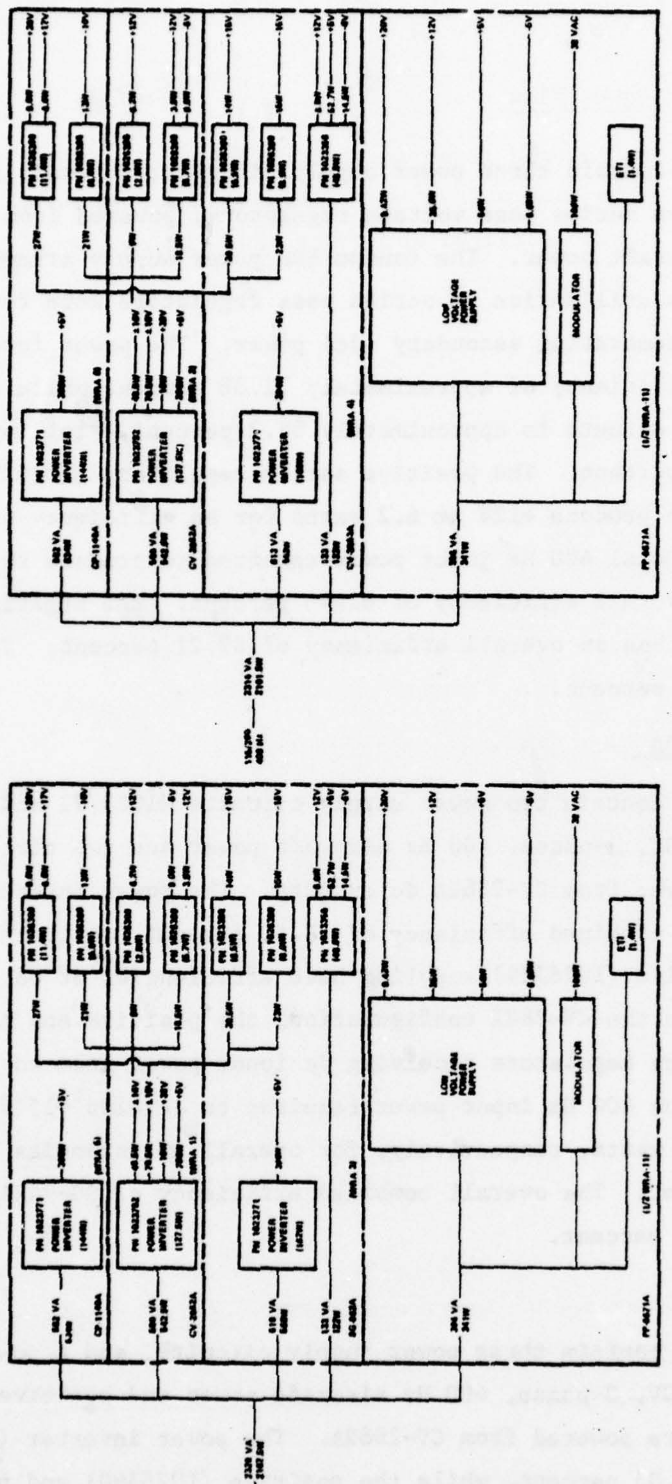


Figure 2-3. OL-82A/AYS

CV-2882A

WRA's 1 and 2, contain three power supply circuits; a power inverter and positive and negative series pass voltage regulators, powered from 115/200V, 3-phase, 400 Hz aircraft power. The tandum SRA power supply arrangement in these WRA's plus the utilization of series pass regulators were found to be inefficient methods of generating secondary (dc) power. The power inverter (1023782) +5V output has an efficiency of approximately 71.88 percent while the efficiency of the remaining dc outputs is approximately 89.2 percent, yielding an overall efficiency of 76.5 percent. The positive series regulators (1026390 requires 9 watts input power to produce +12V at 6.2 watts for an efficiency of 68.89 percent, however, the total 400 Hz input power required to produce this output is 10.1 watts for an overall efficiency of 61.45 percent. The negative series regulator (1026389) has an overall efficiency of 62.21 percent. The overall WRA efficiency is 74.93 percent.

SG-962A/CV-2883A

WRA's 3 and 4, contain two power supply circuits (1023771 and 1023358) powered from 115/200V, 3-phase, 400 Hz aircraft power and two circuits (1026389 and 1026390) are power from CV-2882A dc outputs. The power inverter (1023771) +5 Vdc output has a combined efficiency of 68.50 percent, while the positive (1026390) and negative (1026389) supplied have efficiencies of 68.29 percent respectively. As in the CV-2882 configuration, the positive and negative supplies are series pass regulators receiving dc input power from an inverter circuit. Therefore, the 400 Hz input power required to develop +15 Vdc and -15 Vdc was 23 and 25.8 watts, respectively, for overall efficiencies of 60.87 percent and 58.1 percent. The overall combined efficiency of SG-962A/CV-2883 was 66.56 percent/68.21 percent.

CP-1140A

WRA's 5 and 6, contain three power supply circuits, and a power inverter power off of 115/200V, 3-phase, 400 Hz aircraft power and positive and negative series regulators are powered from CV-2882A. The power inverter (1023771) had an efficiency of 73.03 percent, while the positive (1026390) and negative (10236389) regulators had efficiencies of 57.87 percent and 61.91 percent respectively. Since the positive and negative regulators derived their power

from dc supplies in CV-2882 the efficiency of each must be modified by the power supply loss in CV-2882 to determine the overall efficiency from the 400 Hz aircraft power. The combined efficiencies for each regulator is 5.54 percent and 55.22 percent and the overall WRA efficiency is 71.92%.

PP-6671

WRA 11, contains two power supply circuits operating off of 115/200V, 3-phase, 400 Hz aircraft power. Detailed data on this unit was not available down to the SRA level, and therefore was treated as two dc supplies with +20V at 9.42W, +12V at 25W, +5V at 56W, and -5V at 6.68W outputs on each. PP-6671 also contained a modulator circuit that provided 38 Vac power to each drum WRA. The overall efficiency of this WRA was measured at 59.97 percent.

2.1.5.4.2 APS-116, Radar Set

The radar subsystem is comprised of four WRA's containing internal power supply circuitry:

WRA 1, PP-6633 - Programmer/Power Supply, PN 718364

WRA 2, T-1203 - Transmitter, PN 719214

WRA 3, CV-2852 - Signal Data Converter - Storer, PN 711451-9

WRA 4, C-8788 - Radar Set Control, PN 71146-5

A detailed examination of each WRA failed to reveal any commonality between power supply modules. (The amount of data available on this subsystem was very limited and late in arriving; therefore, the level of analysis was less than that performed on the other six subsystems.) The radar set commonality factor is 0.091. Power flow and accounting is shown in Figure 2-4.

T-1203

This unit contains three power supply modules, one series pass and two unregulated transformer rectifiers, operating in the +7V of 3 kV range at 103.5 watts to 0.3 watts. The average power supply efficiency is 87.56 percent.

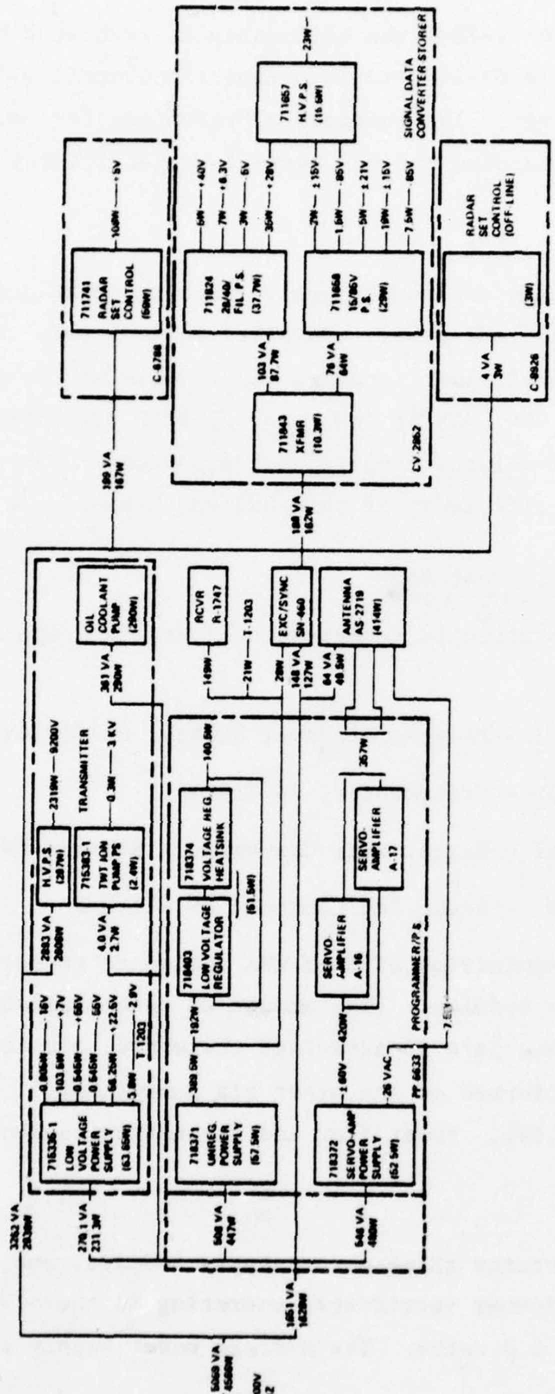


Figure 2-4. APS-116

PP-6633

This unit contains three power supply modules, two transformer/rectifier/series pass circuits and one series pass regulator. The efficiency of these modules range from 72.92 percent to 89.06 percent, with an average WRA efficiency of 75.73 percent.

CV-2852

This unit contains three power supplies, two transformer/rectifier/series pass and one series pass regulator. Their efficiencies range from 11.11 percent to 89.99 percent with an average WRA efficiency of 87.56 percent.

CV-8788

This unit contains one power supply whose efficiency is 64.67 percent.

2.1.5.4.3 ASA-82, Tactical Acoustic Indicator Group (TDS)

The TDS subsystem is comprised of six WRA's containing internal power supply circuitry:

WRA 1, IP-1051 - Pilot Display, PN 231502
WRA 2, IP-1052 - Auxiliary Readout Unit, PN 231560
WRA 3, IP-1053 - Copilot Display, PN 231503
WRA 4, IP-1054 - TACCO Display, PN 231504
WRA 5, IP-1054 - SENSO Display, PN 231504
WRA 6, CV-2806 - Display Generator Unit, PN 231507

Power flow and accounting are shown in Figure 2-5.

A detail review of each WRA identified the use of 17 unique types of power supplies used in 38 applications throughout this subsystem. All power supply circuits except one are standard transformer/rectifier/series pass regulators which dissipate large amounts of energy and, therefore, have relatively low efficiency. The high voltage power supply was a standard transformer rectifier configuration. The average subsystem efficiency for the 115/200V, 3-phase, 400 Hz configuration was 55.93 percent with individual WRA efficiencies ranging from 44.64 percent to 60.75 percent. This resulted in

1356.5 watts being dissipated in power supply circuitry. The TDS power supply commonality factor is 0.579.

IP-1051

Pilot Display contains one transformer feeding four series pass regulators. DC outputs from VR2 and VR4 feed the high voltage dc/dc converter. The power supply output voltages range from +5 Vdc to ±85 Vdc with efficiencies from 46.89 percent to 69.98 percent for low voltage supplies and 43.16 percent for the 10 KV supply. The total power supply dissipation for a 437 watt input was 195.4 watts for an average efficiency of 55.29 percent.

IP-1052

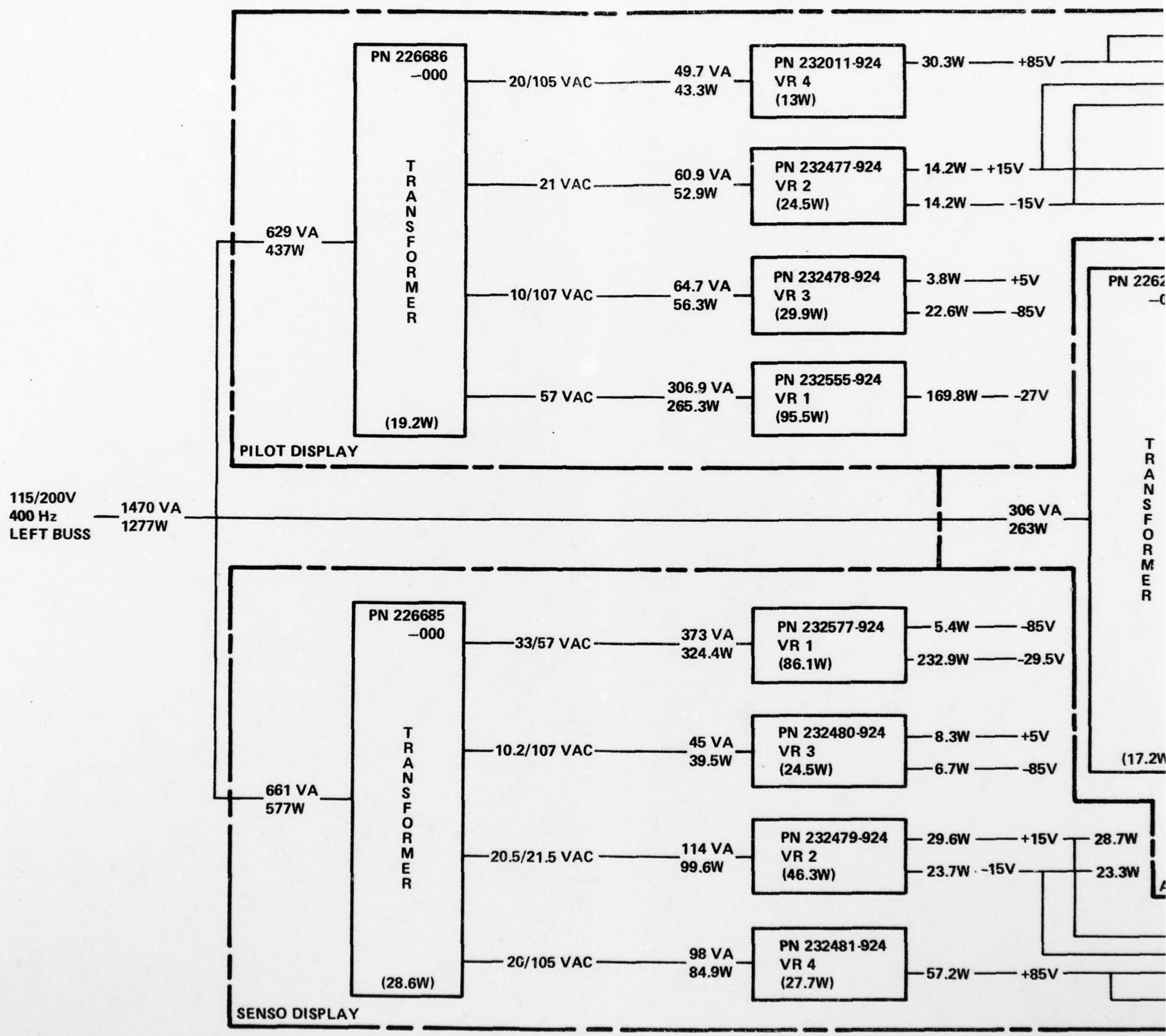
Auxiliary Readout Unit contains a transformer feeding five series pass regulators. DC outputs from VR2 and VR4 feed the 10 KV power supply. Output voltages of VR1 through VR5 range from +5V to ±85 Vdc, with efficiencies from 36.42 percent to 85.45 percent on the unregulated supply and 43.16 percent for the 10 KV dc/dc converter. The total power dissipated for a 263 watt input was 119.0 watts for an average efficiency of 54.75 percent.

IP-1053

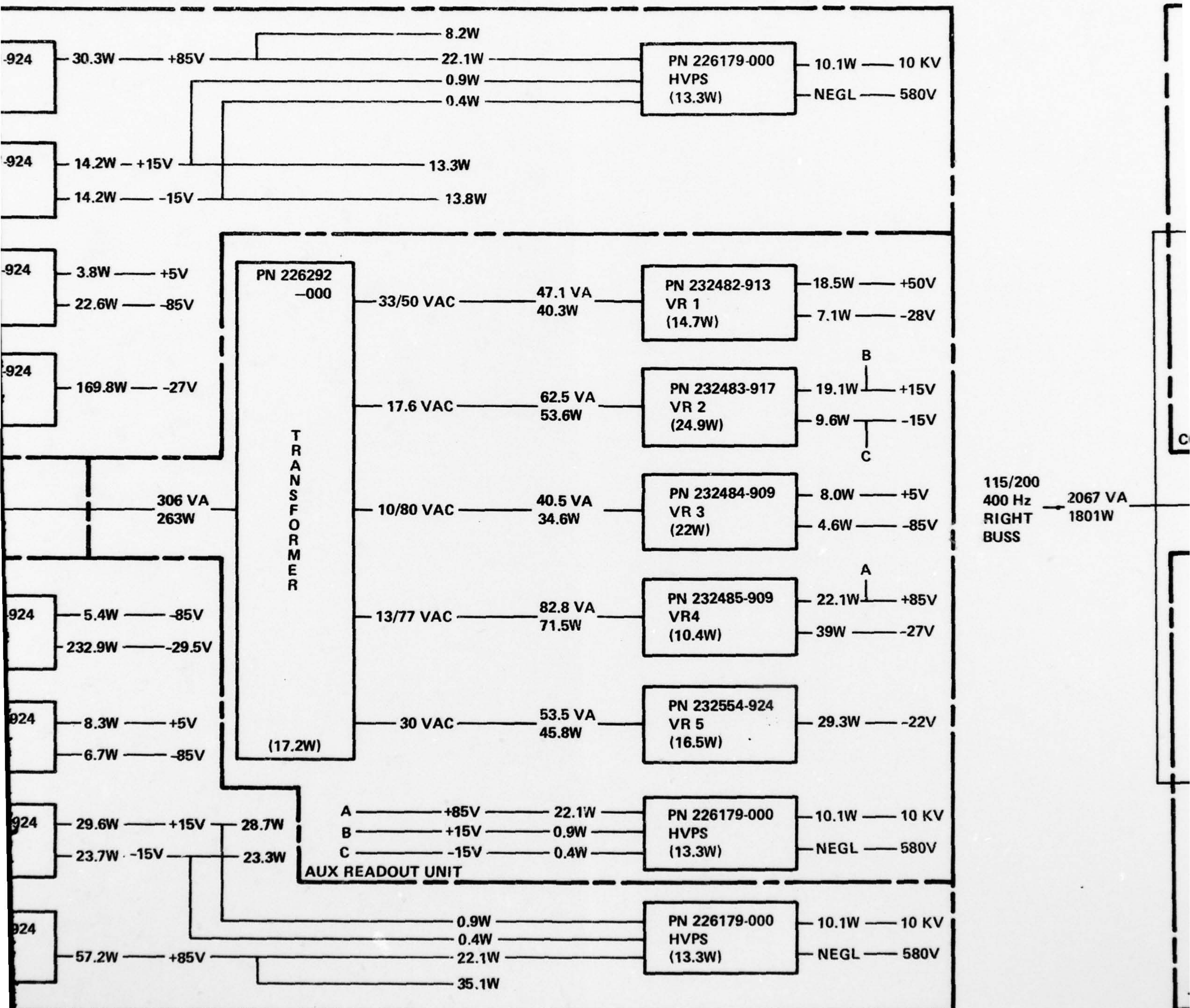
Copilot Display contains one transformer feeding four series pass regulators. The high voltage power supply receivers dc inputs from VR2 and VR4. Output voltages for VR1 through VR4 range from +5 Vdc to ±85 Vdc with efficiency from 37.83 percent to 73.58 percent. The total power dissipated for a 552 watt input was 217.1 watts for an average efficiency of 60.67 percent.

IP-1054

TACCO/SENSO Displays contain one transformer feeding four series pass regulators. The high voltage power supply receives dc inputs from VR2 and VR4. Output voltages for VR1 through VR4 range from +5 Vdc to ±85 Vdc with efficiencies from 37.98 percent to 73.46 percent. The total power dissipated with a 577 watt input was 226.5 watts for an average efficiency of 60.75 percent.

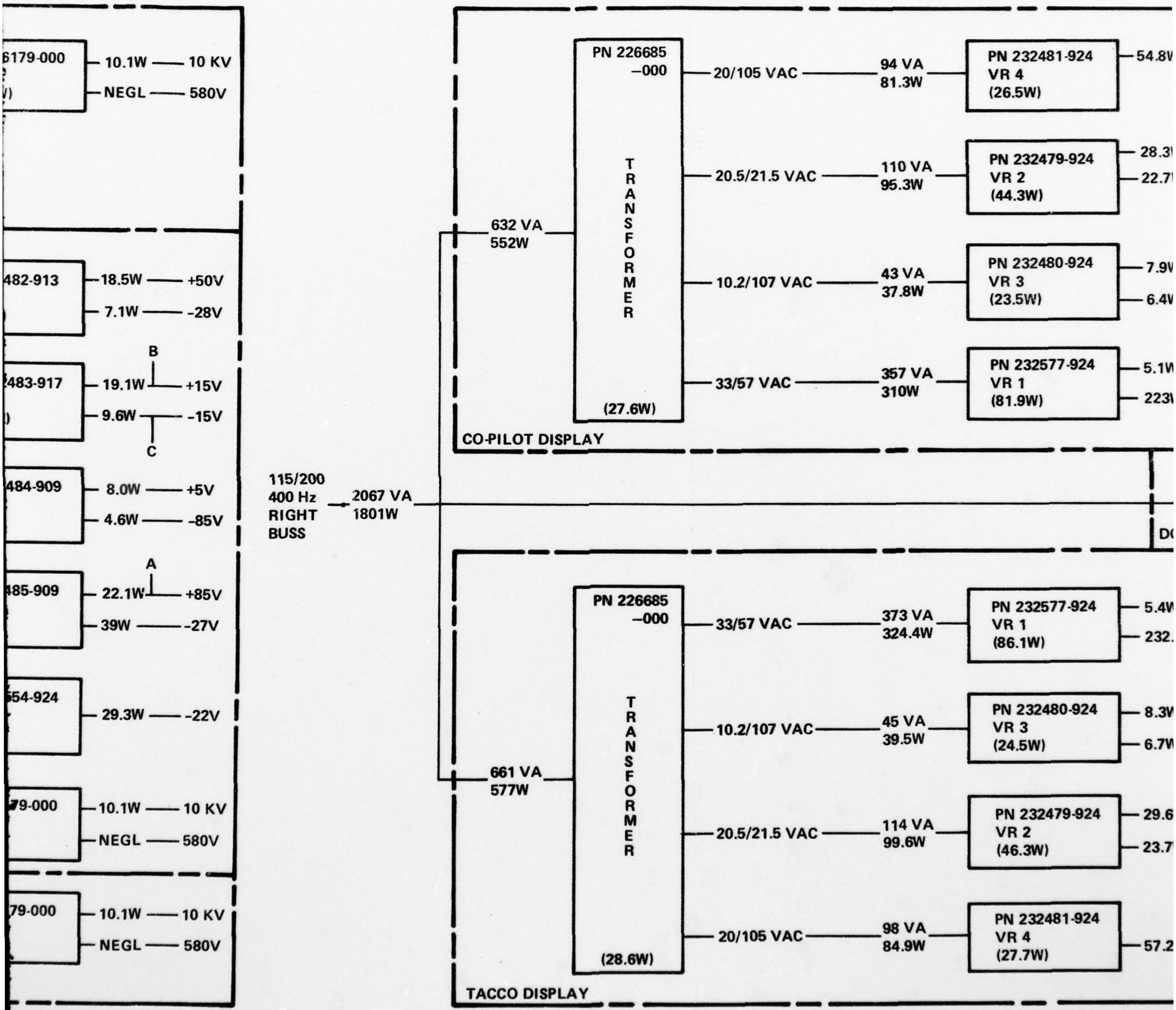


115/200V
400 Hz
LEFT BUSS
1470 VA
1277W
PILOT DISPLAY
629 VA
437W
PN 226686
–000
TRANSFORMER
(19.2W)
20/105 VAC
49.7 VA
43.3W
PN 232011-924
VR 4
(13W)
30.3W
+85V
21 VAC
60.9 VA
52.9W
PN 232477-924
VR 2
(24.5W)
14.2W
+15V
14.2W
-15V
10/107 VAC
64.7 VA
56.3W
PN 232478-924
VR 3
(29.9W)
3.8W
+5V
22.6W
-85V
57 VAC
306.9 VA
265.3W
PN 232555-924
VR 1
(95.5W)
169.8W
-27V
306 VA
263W
TRANSFORMER
SENSO DISPLAY
661 VA
577W
PN 226685
–000
TRANSFORMER
(28.6W)
33/57 VAC
373 VA
324.4W
PN 232577-924
VR 1
(86.1W)
5.4W
-85V
232.9W
-29.5V
10.2/107 VAC
45 VA
39.5W
PN 232480-924
VR 3
(24.5W)
8.3W
+5V
6.7W
-85V
20.5/21.5 VAC
114 VA
99.6W
PN 232479-924
VR 2
(46.3W)
29.6W
+15V
28.7W
23.7W
-15V
23.3W
20/105 VAC
98 VA
84.9W
PN 232481-924
VR 4
(27.7W)
57.2W
+85V

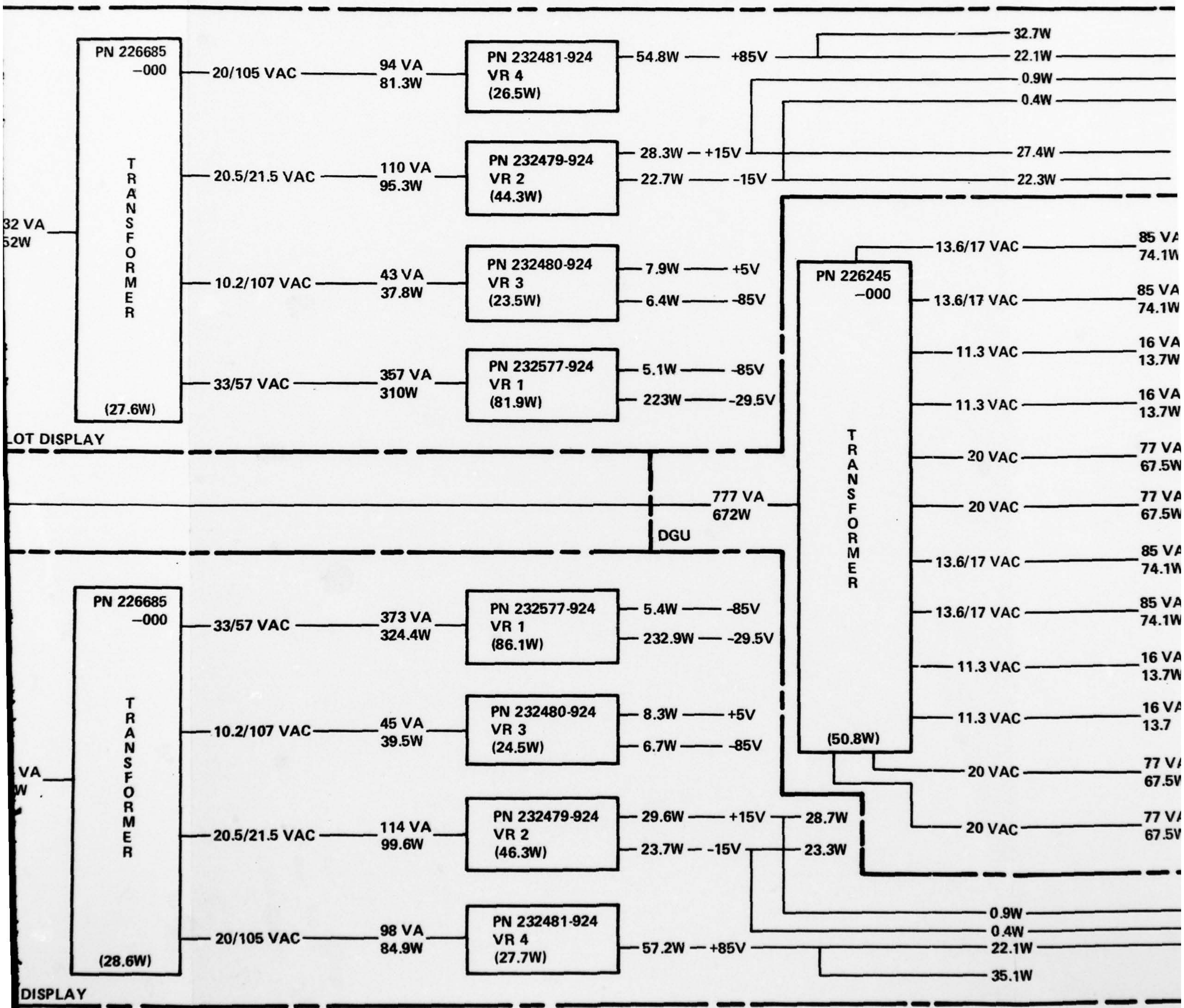


-924
30.3W
+85V
8.2W
22.1W
0.9W
0.4W
PN 226179-000
HVPS
(13.3W)
10.1W
10 KV
NEGL
580V
-924
14.2W
+15V
13.3W
14.2W
-15V
13.8W
-924
3.8W
+5V
22.6W
-85V
-924
169.8W
-27V
PN 226292
-000
TRANSFORMER
(17.2W)
306 VA
263W
33/50 VAC
47.1 VA
40.3W
PN 232482-913
VR 1
(14.7W)
18.5W
+50V
7.1W
-28V
17.6 VAC
62.5 VA
53.6W
PN 232483-917
VR 2
(24.9W)
B
19.1W
+15V
9.6W
-15V
C
10/80 VAC
40.5 VA
34.6W
PN 232484-909
VR 3
(22W)
8.0W
+5V
4.6W
-85V
115/200
400 Hz
RIGHT
BUSS
2067 VA
1801W
924
5.4W
-85V
232.9W
-29.5V
13/77 VAC
82.8 VA
71.5W
PN 232485-909
VR4
(10.4W)
A
22.1W
+85V
39W
-27V
924
8.3W
+5V
6.7W
-85V
30 VAC
53.5 VA
45.8W
PN 232554-924
VR 5
(16.5W)
29.3W
-22V
924
29.6W
+15V
28.7W
23.7W
-15V
23.3W
A
+85V
22.1W
B
+15V
0.9W
C
-15V
0.4W
PN 226179-000
HVPS
(13.3W)
10.1W
10 KV
NEGL
580V
AUX READOUT UNIT
924
57.2W
+85V
0.9W
0.4W
22.1W
35.1W
PN 226179-000
HVPS
(13.3W)
10.1W
10 KV
NEGL
580V

2



6179-000
10.1W — 10 KV
NEGL — 580V
482-913
18.5W — +50V
7.1W — -28V
483-917
19.1W — +15V
9.6W — -15V
B
C
484-909
8.0W — +5V
4.6W — -85V
485-909
22.1W — +85V
39W — -27V
A
554-924
29.3W — -22V
79-000
10.1W — 10 KV
NEGL — 580V
79-000
10.1W — 10 KV
NEGL — 580V
115/200
400 Hz
RIGHT
BUSS
2067 VA
1801W
632 VA
552W
PN 226685
-000
TRANSFORMER
(27.6W)
20/105 VAC
94 VA
81.3W
PN 232481-924
VR 4
(26.5W)
20.5/21.5 VAC
110 VA
95.3W
PN 232479-924
VR 2
(44.3W)
10.2/107 VAC
43 VA
37.8W
PN 232480-924
VR 3
(23.5W)
33/57 VAC
357 VA
310W
PN 232577-924
VR 1
(81.9W)
CO-PILOT DISPLAY
661 VA
577W
PN 226685
-000
TRANSFORMER
(28.6W)
33/57 VAC
373 VA
324.4W
PN 232577-924
VR 1
(86.1W)
10.2/107 VAC
45 VA
39.5W
PN 232480-924
VR 3
(24.5W)
20.5/21.5 VAC
114 VA
99.6W
PN 232479-924
VR 2
(46.3W)
20/105 VAC
98 VA
84.9W
PN 232481-924
VR 4
(27.7W)
TACCO DISPLAY



PN 226685
-000
TRANSFORMER
(27.6W)
20/105 VAC
20.5/21.5 VAC
10.2/107 VAC
33/57 VAC
94 VA
81.3W
110 VA
95.3W
43 VA
37.8W
357 VA
310W
PN 232481-924
VR 4
(26.5W)
PN 232479-924
VR 2
(44.3W)
PN 232480-924
VR 3
(23.5W)
PN 232577-924
VR 1
(81.9W)
54.8W
+85V
28.3W
+15V
22.7W
-15V
7.9W
+5V
6.4W
-85V
5.1W
-85V
223W
-29.5V
32.7W
22.1W
0.9W
0.4W
27.4W
22.3W
32 VA
52W
LOT DISPLAY
777 VA
672W
DGU
PN 226245
-000
TRANSFORMER
(50.8W)
13.6/17 VAC
13.6/17 VAC
11.3 VAC
11.3 VAC
20 VAC
20 VAC
13.6/17 VAC
13.6/17 VAC
11.3 VAC
11.3 VAC
20 VAC
20 VAC
85 VA
74.1W
85 VA
74.1W
16 VA
13.7W
16 VA
13.7W
77 VA
67.5W
77 VA
67.5W
85 VA
74.1W
85 VA
74.1W
16 VA
13.7W
16 VA
13.7
77 VA
67.5W
77 VA
67.5W
PN 226685
-000
TRANSFORMER
(28.6W)
33/57 VAC
10.2/107 VAC
20.5/21.5 VAC
20/105 VAC
373 VA
324.4W
45 VA
39.5W
114 VA
99.6W
98 VA
84.9W
PN 232577-924
VR 1
(86.1W)
PN 232480-924
VR 3
(24.5W)
PN 232479-924
VR 2
(46.3W)
PN 232481-924
VR 4
(27.7W)
5.4W
-85V
232.9W
-29.5V
8.3W
+5V
6.7W
-85V
29.6W
+15V
23.7W
-15V
28.7W
23.3W
57.2W
+85V
0.9W
0.4W
22.1W
35.1W
VA
W
DISPLAY

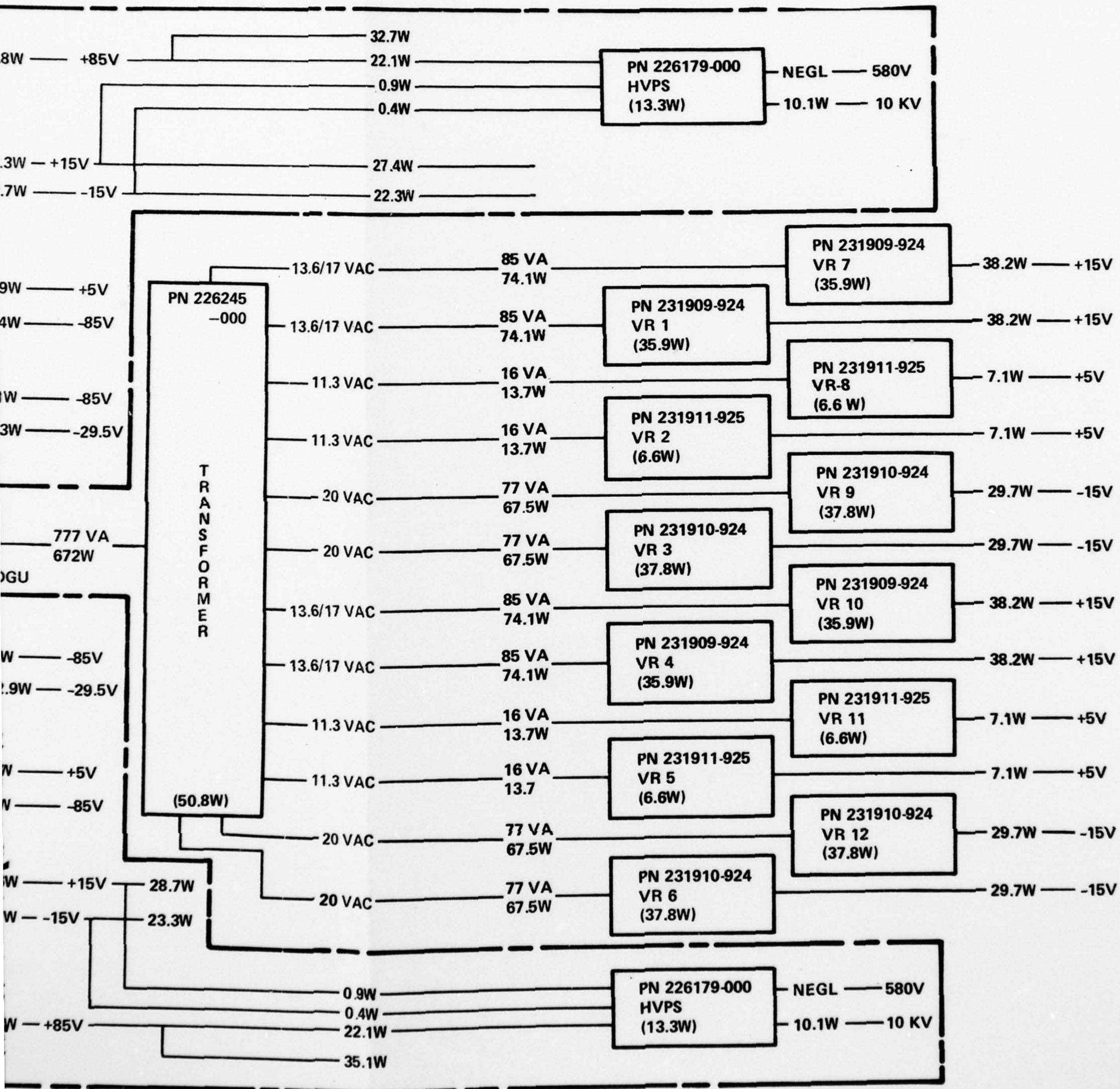


Figure 2-5. ASA-82

CV-2806

Display Generator Unit contains one transformer feeding 12 rectifier series pass regulators. The output voltages are +5 Vdc (VR2, 5, 8, 11), +15 Vdc (VR1, 4, 7, 10), and -15 Vdc (VR3, 6, 9, 12) at efficiencies of 44.0 percent to 51.82 percent. The power dissipated for a 672 watt input was 372 watts for an average efficiency at 44.64 percent.

2.1.5.4.4 ARC-153A, HF Radio

The HF Radio subsystem is comprised of three WRA's containing internal power supply circuitry:

WRA 1, AM-6384 - RF Amplifier, PN 792-6422-005

WRA 2, RT-1016 - Receiver/Transmitter, PN 792-6390-008

WRA 3, CU-1985 - Antenna Coupler, PN 792-6239-002

Power flow and accounting are showing in Figure 2-6. The HF radio power supply commonality factor is 0.167.

A detailed review of each WRA identified the use of six unique series pass regulator power supply subassemblies, five received 400 Hz power through input transformer and one (HF R/T power supply) received dc input from AM-6384. The efficiency of the HF R/T power supply with 36.8 watt load was 42.30 percent. (The serial power configuration reduces the overall efficiency to 20.67 percent or 178.1 watts of 400 Hz power are required to produce 36.8 watts of secondary power). The remaining power supply efficiencies range from 43.2 percent to 74.38 percent.

The total power supply dissipation in this subsystem was watts for an overall efficiency of 60.40 percent.

2.1.5.4.5 OR-89A/AA, Infrared Detecting Group

The IR subsystem contains three WRA's with internal power supplies:

WRA 1, PP-7179 - Video Converter Power Supply, PN 708002
WRA 2, PP-1069 - IR Viewer, PN 708001
WRA 3, C-8759 - IR Control Converter, PN 708003

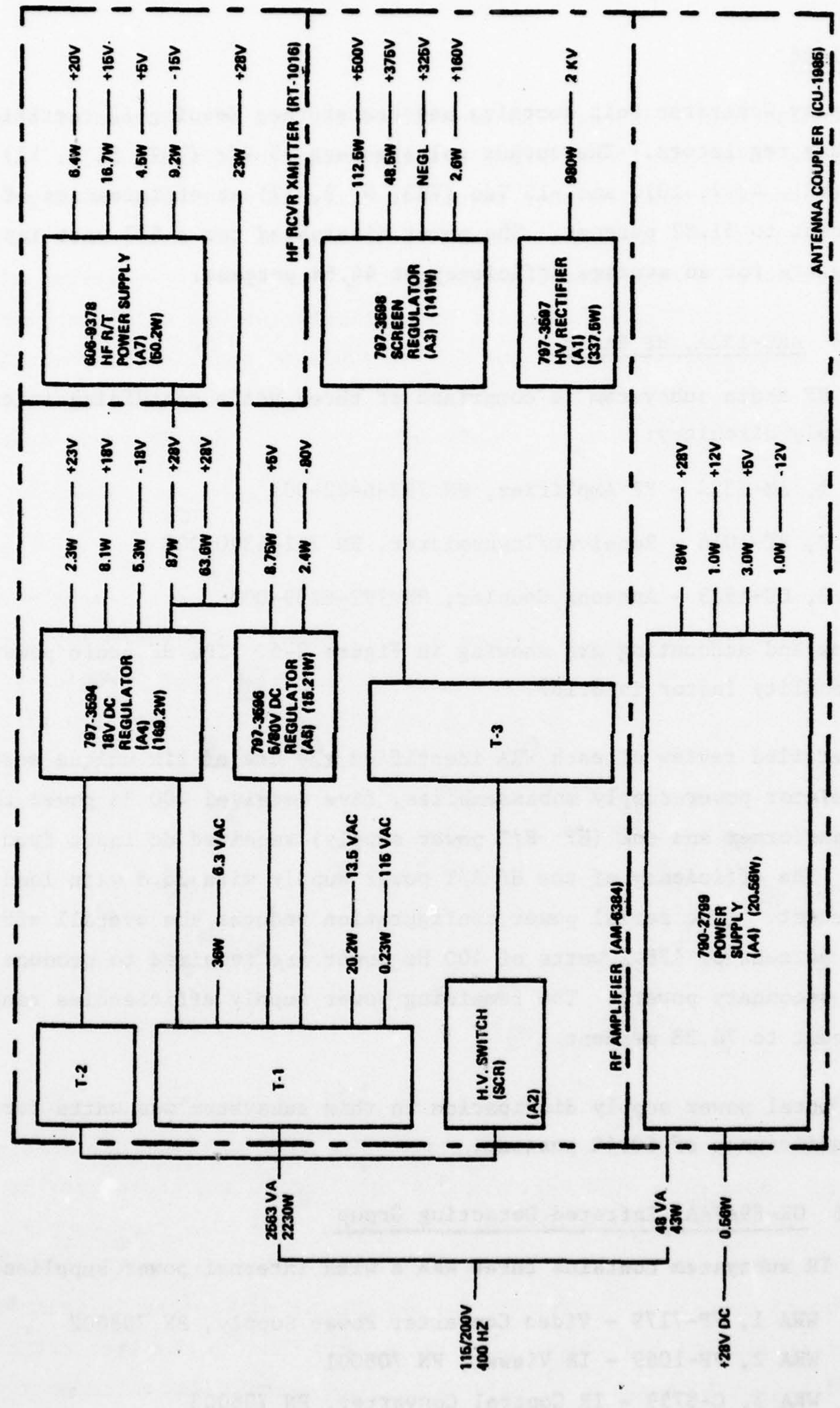


Figure 2-6. ARC-153A

A detailed review of each WRA identified the use of 12 types of power supplies used in 16 applications throughout the subsystem (Figure 2-7). Standard transformer/rectifier/series pass regulator circuits were used on 12 power supply modules while 1 used a dc/dc converter circuit and the remaining 3 were special high power unregulated configurations. The average subsystem efficiency for the 115/200V, 3-phase, 400 Hz configuration was 63.04 percent for regulated supplies and 95.09 percent for unregulated supplies, with individual power supplies ranging from 21.74 percent to 98.02 percent. This resulted in 438.1 watts being dissipated by power supply modules. The IR power supply commonality factor is 0.313.

PP-7179

Video converter power supply, contains five unique power supply modules which operate off of 115/200V, 3-phase, 400 Hz power. The video regulator (A1 through A4) is a transformer/rectifier/series pass supply providing +15 Vdc at 51 watts. The camera regulator (A5) and ±15V regulator (A6) are also transformer/rectifier/series pass regulators providing +20V at 80 watts and ±15V a 51 watts, respectively. The TEC power module is a high power transformer supply which provides power to the SRC bridge located in IP-1069. The last power supply, Scan Drive electronics, provides 115 Vac at 20 watts to IP-1069 and motor driven signals to the azimuth drive assembly. The overall WRA efficiency was 82.92 percent with individual efficiencies ranging from 58.62 percent to 95.99 percent.

IP-1069

IR viewer contains four unique power supply modules, two series pass, one rectifier/filter, and one dc/dc converter. The 3 kV supply, PS1, dissipates 18 watts in the process of developing 3 kV at 5 watts and therefore, is the most inefficient supply (21.7 percent) in the system. The BIAS Pack supply operates off of -15 Vdc from C-8759 and is the only dc/dc converter in IP-1069 and operates at 75 percent efficiency. The SRC BRIDGE dissipates 24 watts in the process of developing 140 Vdc at 1290 watts, and thus is the most efficient supply (98 percent) in the FLIR subsystem. The overall WRA efficiency was 95.96 percent.

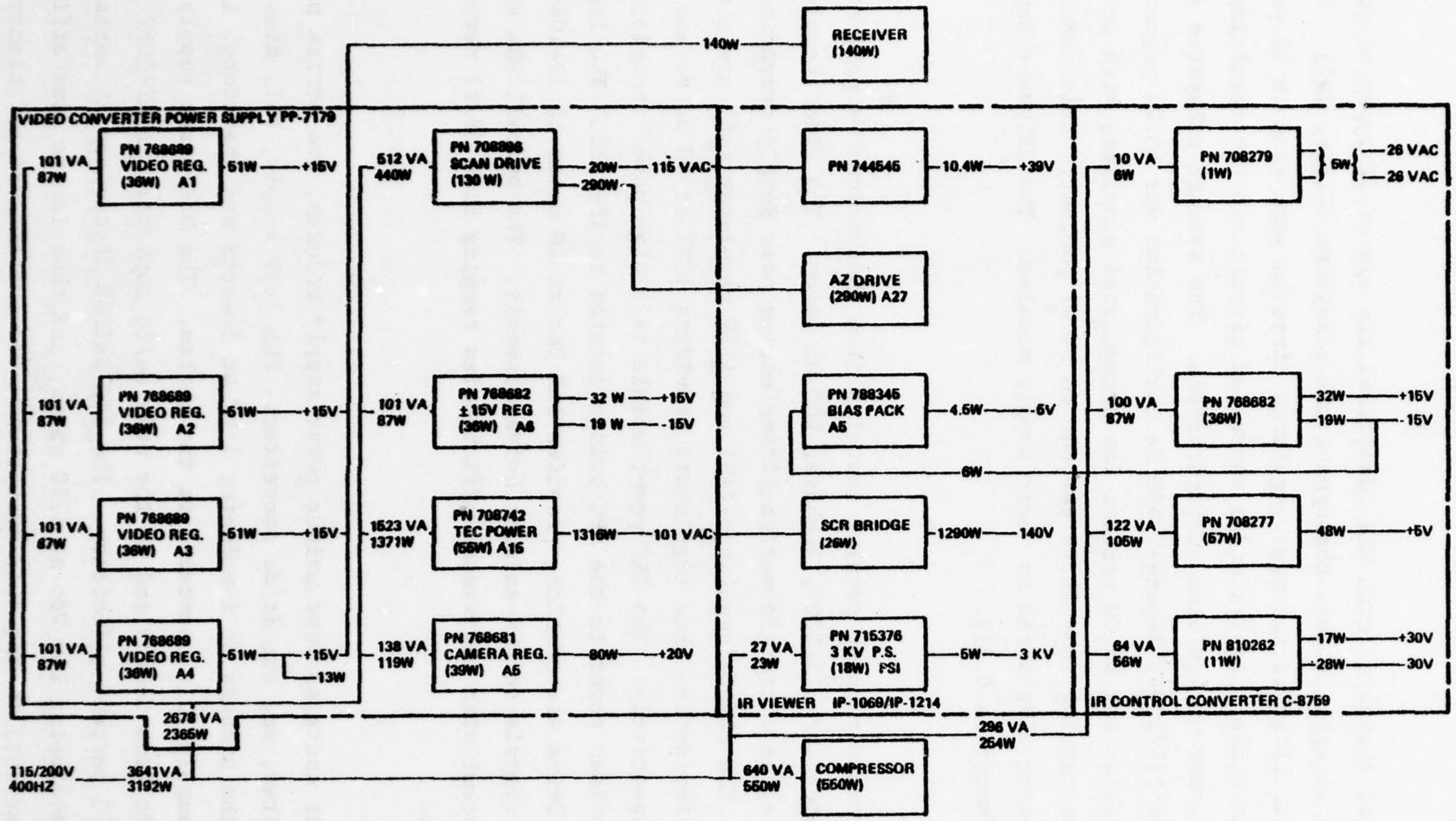


Figure 2-7. OR-89A/AA

C-8759

This unit contains three unique transformer/rectifier/series pass regulators and one whose circuitry is the same as the $\pm$15V module used in PP-7179. The efficiency of these modules range from 45.71 percent to 83.33 percent, with an average subsystem efficiency of 58.7 percent.

2.1.5.4.6 AYK-10A, Digital Computer

The digital computer subsystem has eight power supply WRA's:

WRA 1	PP-6679 - Power Supply No. 1, PN 7131700
WRA 2	PP-6675 - Memory dc/dc Converter, PN 7131775
WRA 3	PP-6676 - CPU dc/dc Converter, PN 7511300
WRA 4	PP-6677 - I/O dc/dc Converter, PN 7511200
WRA 5	PP-6678 - Power Supply No. 2, PN 7131700
WRA 6	PP-6675 - Memory dc/dc Converter, PN 7131775
WRA 7	PP-6676 - CPU dc/dc Converter, PN 7511300
WRA 8	PP-6677 - I/O dc/dc Converter, PN 7511200

WRA's 1 and 2 contain two types of inverters (A and B), one provides an output voltage of 100 $\pm$3 Vdc and the other 100 $\pm$1 Vdc. The circuitry used in each power supply is standard switched mode technology popular during the hardware design phase and, therefore, have higher efficiencies than experienced on other S-3A power supplies. The average subsystem efficiency for the 115/200V, 3-phase, 400 Hz input configuration was 62.88 percent with individual WRA efficiencies ranging from 70.85 percent to 87.44 percent. This resulted in 694 watts being dissipated in the power supply circuitry. The computer power supply commonality factor is 0.667. See Figure 2-8.

PP-6679

Power supply No. 1 contains one Type B inverter and two Type A inverters. The Type B inverter output is 100 $\pm$3 Vdc and the Type B inverter is 100 $\pm$1 Vdc. The power dissipated in WRA 1 is 123 watts for a 979 watt input, thus, proving an average efficiency of 87.44 percent.

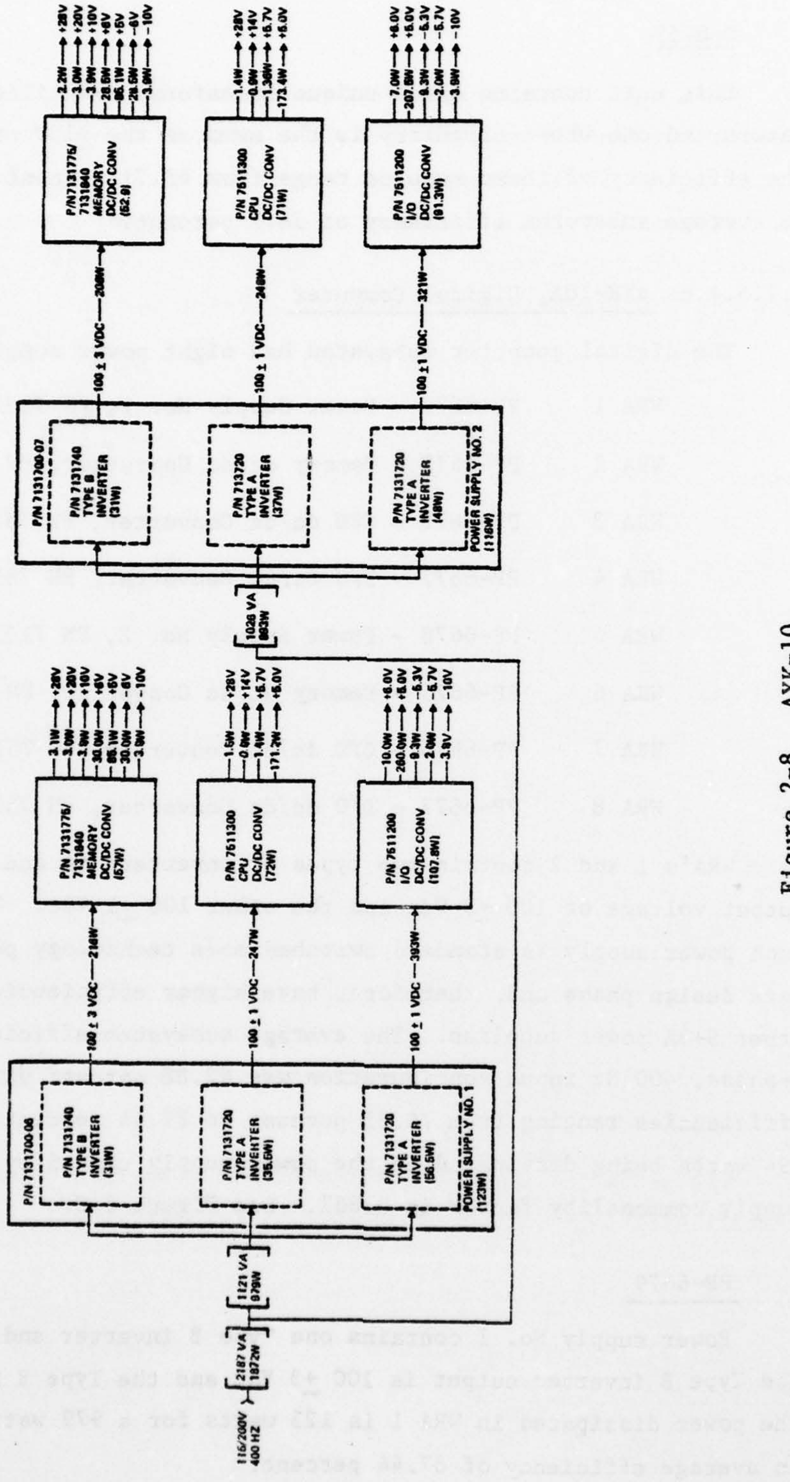


Figure 2-8. AYK-10

PP-6675

Memory dc/dc converter receives its input (100 $\pm$3 Vdc) from the Type B inverter in PP-6679 and provides dc outputs from -10 to +28V at an average efficiency of 70.85 percent. This relatively low efficiency is a result of the large amount of low voltage power (5 to 6 Vdc) generated in the unit. The overall efficiency from the 400 Hz power bus to PP-6675 output ports is 64.37 cent for WRA 2 application and 64.88 percent for WRA 6 application.

PP-6676

CPU dc/dc converter receives its input power (100 $\pm$1 Vdc) from a Type A inverter in PP-6679 and provides output voltages from +5 to + 28 Vdc at an average efficiency of 73.61 percent. The overall efficiency from the 400 Hz power bus to the PP-6676 output parts is 61.95 percent when used for WRA 3 and 62.12 percent for WRA 7.

PP-6677

I/O dc/dc converter receives input power from PP-6679 and provides output voltages for -10 to +6 Vdc an average efficiency of 72.57 percent. The overall efficiency from the 400 Hz power bus to the PP-6677 output is 63.46 percent when used in the WRA 4 position and 62.26 percent when used for WRA 7.

PP-6678

Power Supply No. 2 contain one Type B and two Type A inverters. The Type B output is 100 $\pm$3 Vdc and the Type A is 100 $\pm$1 Vdc. The power dissipation of WRA 7 is 116 watts for an 893 watt input, thus, providing an average efficiency of 87.01 percent.

The serial arrangement of the AYK-10 subsystem power supplies provide an overall efficiency of 62.88 percent.

2.1.5.4.7 AYN-5, Airspeed-Altitude Computer (AACS)

The AACS subsystem electronics is contained in one WRA, CP-1077 PN 19820000, Figure 2-9. The internal power supply circuitry is divided

between two identical transformer/rectifier/series pass regulator modules. Each supply is powered from 115/200V, 3-phase, 400 Hz aircraft power and provide -25 to +20 Vdc and 5.7 to 26 Vac output power. The dc efficiency of each module is 76.74 percent, while the ac efficiency is 89.21 percent. The AACS power supply commonality factor is 1.000.

2.1.5.5 Power Supply Selection

The data compiled in paragraph 2.1.5.2 was reviewed to determine the typical power supply output/functions and grouped in voltage/power categories, as shown in Table 2.10. From this tabulation, typical power supply modules were selected from each subsystem for evaluation by the power supply design subcontractor; Engineered Magnetics Division, Gulton Industries, Inc., Hawthorne, California (EMD).

The power supplies selected included:

- ARC153A, HF Radio

  AM-6384; RF amplifier power supply
  797-3594, 18V regulator
  797-3596, 5/80V regulator
  797-3597, high voltage rectifier
  797-3598, screen regulator

- RT-1016; RCVR/XMTR power supply

  606-9378

- APS116, Radar

  T-1203; Transmitter
  719292-2, high voltage power supply
  715335, low voltage power supply

- ASA82, Tactical Acoustic Indicator Group

  CV-2806; DGU power supply
  226245-000, transformer
  231909-909, +15V regulator

AD-A066 526 LOCKHEED-CALIFORNIA CO BURBANK ADVANCED AVIONICS DEPT F/G 9/5
ANALYSIS OF THE IMPACT OF A 270 VDC POWER SOURCE ON THE AVIONIC--ETC(U)
NOV 78 N62269-78-C-0007
UNCLASSIFIED LR-28780 NADC-79012-60 NL

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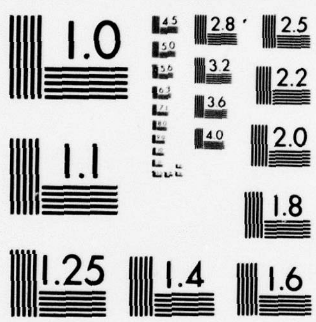


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

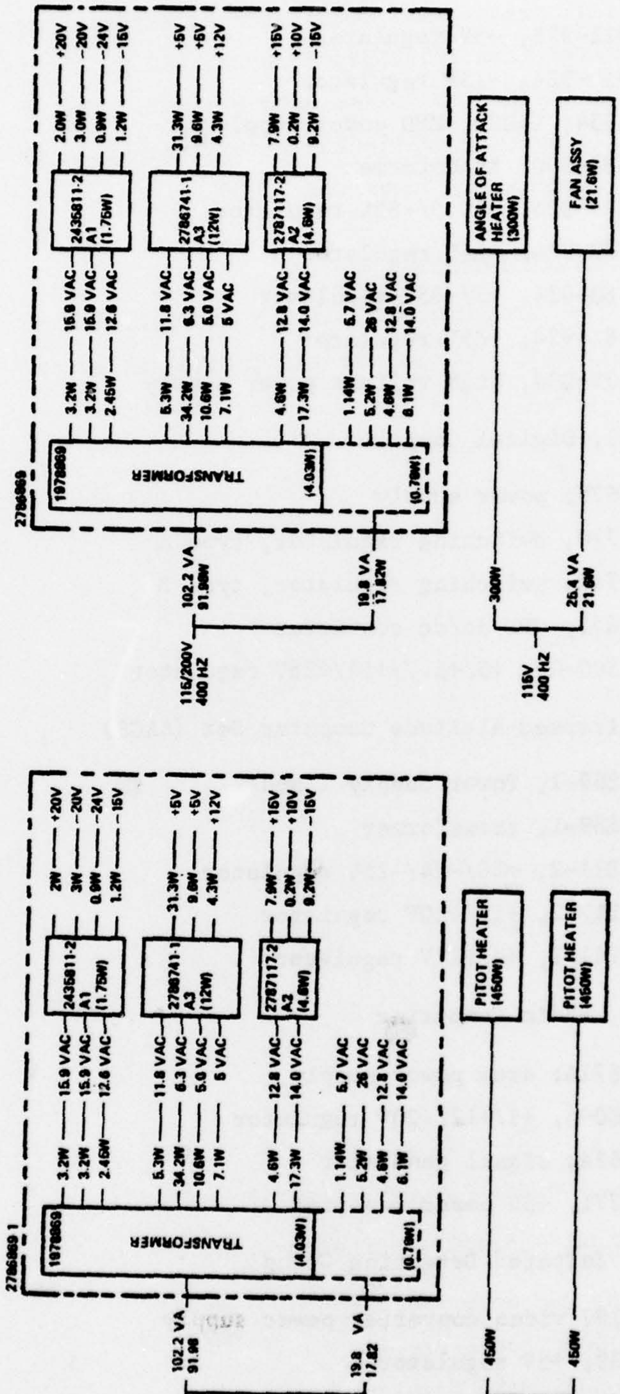


Figure 2-9. AYN-5

231911-925, +5V regulator

231910-924, -15V regulator

IP-1054; TACCO, MPD power supply

226685-000, transformer

232577-924, -29.5/-85V regulator

232479-924, ±15V regulator

232480-924, +5/-85V regulator

232481-924, +85V regulator

226179-000, high voltage power supply

- AYK-10A(V), Digital Computer

  PP-6679; power supply

  7131720, switching regulator, type A

  7131740, switching regulator, type B

  PP-6675; CPU dc/dc converter

  7511300-00, +5/+5.7/+14/+28V regulator

- AYN-5A, Airspeed-Altitude Computer Set (AACS)

  2786869-1, Power Supply 1 and 2

  1978869-1, transformer

  2435811-2, ±20/-24/-25V regulator

  2787117-2, ±15/+10V regulator

  2786741-1, +5/+12V regulator

- OL82A/AYS, Radio Computing

  PP-6671A; drum power supply

  621600-4, ±5/+12/+20V regulator

  SQ-962A; signal generator

  1023771, +5V power inverter

- OR-89C/AA Infrared Detecting Group

  PP-7197 video converter power supply

  768689, +5V regulator

  768682, ±15V regulator

  768681, camera regulator

708742, TEC Power

708896, Scan drive

This selection accounts for 62.4 percent of the power supplies used in the seven subsystem study group.

2.1.5.6 Subcontractor Power Supply Analysis

EMD performed a comparative study (400 Hz versus 270 Vdc Aircraft Power) on S-3A power conversion performance and compiled physical data to determine the following parameters on each power supply listed in paragraph 2.1.5.5:

- Input power
- Output power
- Efficiency
- Size
- Weight
- Reliability

Once this study had been completed, EMD prepared new state-of-the-art (SOA) power supply designs using the following criteria as primary objectives:

- 270 Vdc primary power (NADC-VT-TS-7502)
- Full MIL-STD-704B operation
- Improved efficiency
- Improved reliability
- Reduced LCC
- Reduced weight
- Reduced volume

The last five objectives were found to be highly interactive and therefore, required trade-off studies to achieve an optimized design methodology.

2.1.5.6.1 Efficiency Versus Weight/Volume

The efficiency of any power conversion device is directly related to the circuit design utilized. For the purposes of this study, the most efficient circuit form consistent with the requirements of defined performance was chosen for the SOA design. This ground rule places significant restrictions on parts selection and parts population.

Another consideration for improved efficiency lies in the area of magnetic device design. It becomes obvious, when evaluating various magnetic design possibilities, that an optimum magnetic device must become larger and heavier to become more efficient. It, therefore, follows that increased efficiency leads to increased size and weight.

For this reason, the SOA devices used for comparative purposes herein are not necessarily of the smallest size or lightest weight achievable. They are, however, representative of devices optimized for high reliability and improved efficiency while keeping size and weights within prudent limits.

2.1.5.6.2 Reliability Versus Weight/Volume

The reliability inherent in a power conversion device is a product of the following design elements:

- Parts selection (reliability level)
- Parts population
- Thermal stress
- Electrical stress

Within a given set of performance requirements and environmental conditions, we assumed that the parts population (complexity dictated by the SOA design and performance requirements) and parts selection are fixed parameters, and, therefore, reliability is dependent on the thermal environment and electrical stress levels imposed on the components.

To improve reliability, thermal stress is found to be the predominant controlling function, and electrical stress has a lesser effect, assuming, of course, the parts are used within their rated limits.

Operating temperature is greatly dependent on four factors:

- Heat dissipation
- Ambient temperature
- Mass, as related to radiating area and component size
- Available cooling provisions

Figure 2-10 illustrates the general relationship between reliability and weight/volume. Improved equipment reliability increases hardware size and weight. As a result, an optimum relationship between reliability and volume/weight has been designed into the SOA 270 Vdc units for this study.

2.1.5.6.3 Cost of Ownership Considerations

The ultimate intent of this study effort was to describe cost effective design methodologies which would reduce the Navy's weapon system LCC. Therefore, all engineering decisions were influenced by initial cost and LCC trade-off studies.

2.1.5.6.4 270 Vdc Design

For each of the power supply units listed in paragraph 2.1.5.5, one or more new (270 Vdc) power converters were designed to meet the output requirements of the existing equipments. These designs were carried to a depth adequate to allow detailed assessment of:

- Efficiency
- Thermal characteristics
- Voltage stress levels
- Power stress levels
- Component parts
- Mechanical and physical packaging requirements
- Reliability characteristics

The circuit designs were functionally limited to those necessary to meet present performance requirements using existing equipments.

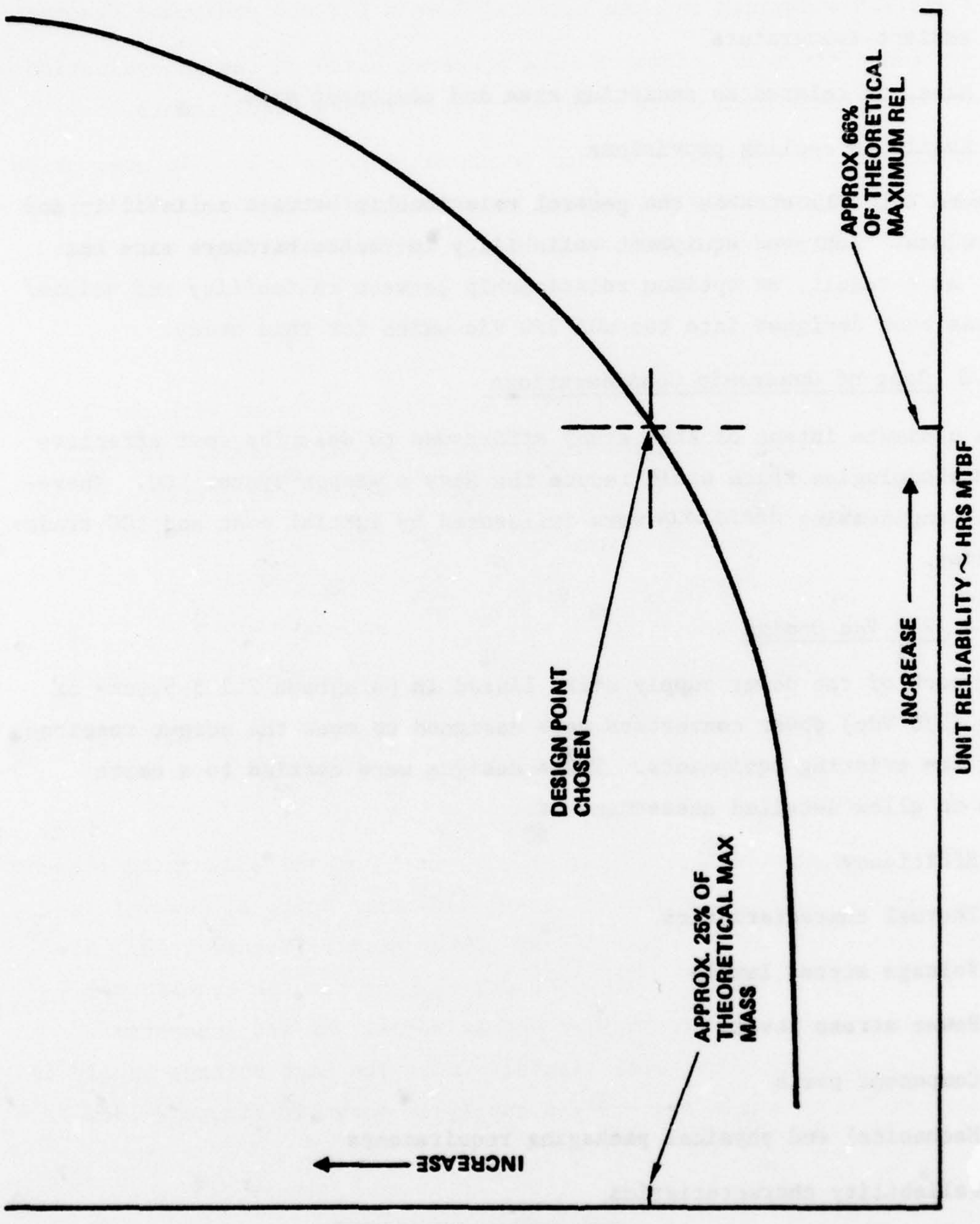


Figure 2-10. Reliability Versus Weight/Volume

Reliability estimates were prepared utilizing the failure figures and methods of MIL-HDBK-217B. Average stress values were estimated based on presently available devices and the required levels for the equipment functions.

Weight and efficiency estimates were prepared based on design evaluation and on past experience with units of similar performance requirements.

A summary of 270 Vdc design effort is shown in Table 2-18. In most cases relatively large weight and power saving were realized with the use of dc/dc converter technology but in a few cases, e.g., AYN-5, the savings were less dramatic.

2.1.5.6.5 400 Hz/270 Vdc Power Supply Comparison

The reduced parts count and circuit simplicity associated with the 270 Vdc design are illustrated in the following comparative evaluation of the TACCO/SENSO Display, IP-1054/ASA-82, which contains four series regulators,

VR1, -29/-80V Regulator	Figure 2-11
VR2, ±15V Regulator	Figure 2-12
VR3, -85/+5V Regulator	Figure 2-13
VR4, +85V Regulator	Figure 2-14

and a high voltage power supply in the 400 Hz configuration. (The latter is a proprietary assembly for which detailed design information was not available.)

The 270 Vdc configuration, (Figure 2-15), designed to replace the present system was divided into four basic circuits; mid range voltage, low voltage, high voltage, and high power. The ±85/-80V power supply (Figure 2-15a) has the exact same circuitry as the ±15/+5V supply except for the transformer. This circuit standardization is carried across normal WRA and subsystem boundaries to help reduce the total aircraft LCC. The high voltage supply is shown in Figure 2-15c, while the -29 Vdc supply is shown in Figure 2-15d.

TABLE 2-18. COMPARISON OF STATE-OF-THE-ART 270 VDC POWER SUPPLIES VERSUS EXISTING S-3A AIRCRAFT POWER SUPPLIES

PHYSICAL AND ELECTRICAL PERFORMANCE CHARACTERISTICS

Unit	400 Hz Sys Input Pwr (Watts)	270 Vdc Sys Input Pwr New (Watts)	Power Out	Power Saved (Watts)	400 Hz Sys Unit Weight (Pounds)	270 Vdc Sys Unit Weight (Pounds)	Delta Weight (Pounds)	400 Hz Sys Volume (In^3)	270 Vdc Sys Volume (In^3)	Delta Volume (In^3)
APS116 Radar HVPS	2606	2576	2319	27.0	18.32	14.05	- 4.27	124.3	171.9	+ 47.6
APS116 LVPS	231.3	189	167.4	42.3	2.57	1.97	-0.60	33.7	46.6	+ 12.9
ARC153A Multiple PS	2230	1781.2	1344.1(O) 1293.9(N)	448.8	39.3	28.0	-11.3	282	418	+136.1
AYN5A Multiple PS	183.96	180.0	139.2	1.38	9.12	6.34	- 2.78	225.6	144	- 81.6
ASA82 DGU PS	672	375	300	297	11.27	7.12	- 4.15	174.3	178.3	+ 4.0
ASA82 TACCO PS	577	395	350.5	182	11.49	7.49	- 4.00	116.8	146.8	+ 30.0
OL82A, PP-6671A PS	682	552	409	130	48.7	18.3	-30.4	1400	546	-854
OL82A, 5V PS	568	523	386	45	7.40	7.05	- .35	115	154.4	+ 39.4
AYK10 Line Reg	979	848.1	856 (O) 803.1(N)	130.9	31.7	13.50	-18.2	1008	384	-624
AYK10 Converter PS	247	244	174.9	3	6.32	6.35	+ .03	138	138	-
OR89C Multiple PS (PP-7197AA)	2365	2155.2	1961	209.8	19.46	10.76	- 8.70	273.5	178.3	- 95.2

(O) 400 Hz Configuration
(N) 270 Vdc Configuration

NOTES

UNLESS OTHERWISE SPECIFIED

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX THE DESIGNATION WITH 2VR1 THRU 2VR4, 3VR1 THRU 3VR4, 4VR1 THRU 4VR4 AS APPLICABLE.

2. RESISTANCE VALUES ARE IN OHMS, 1/2W, ± 5%.

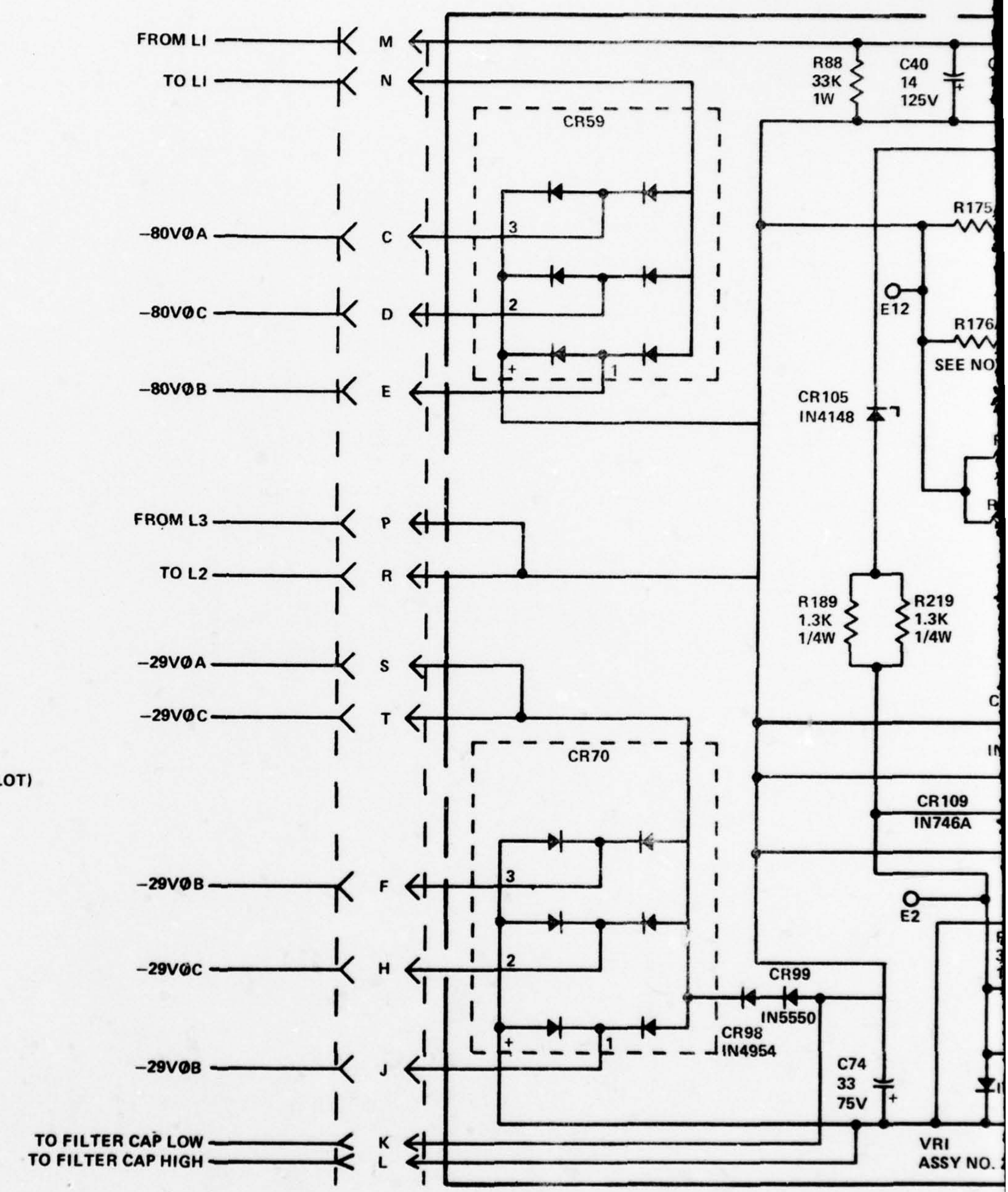
3. CAPACITANCE VALUES ARE IN MICROFARADS, 100V.

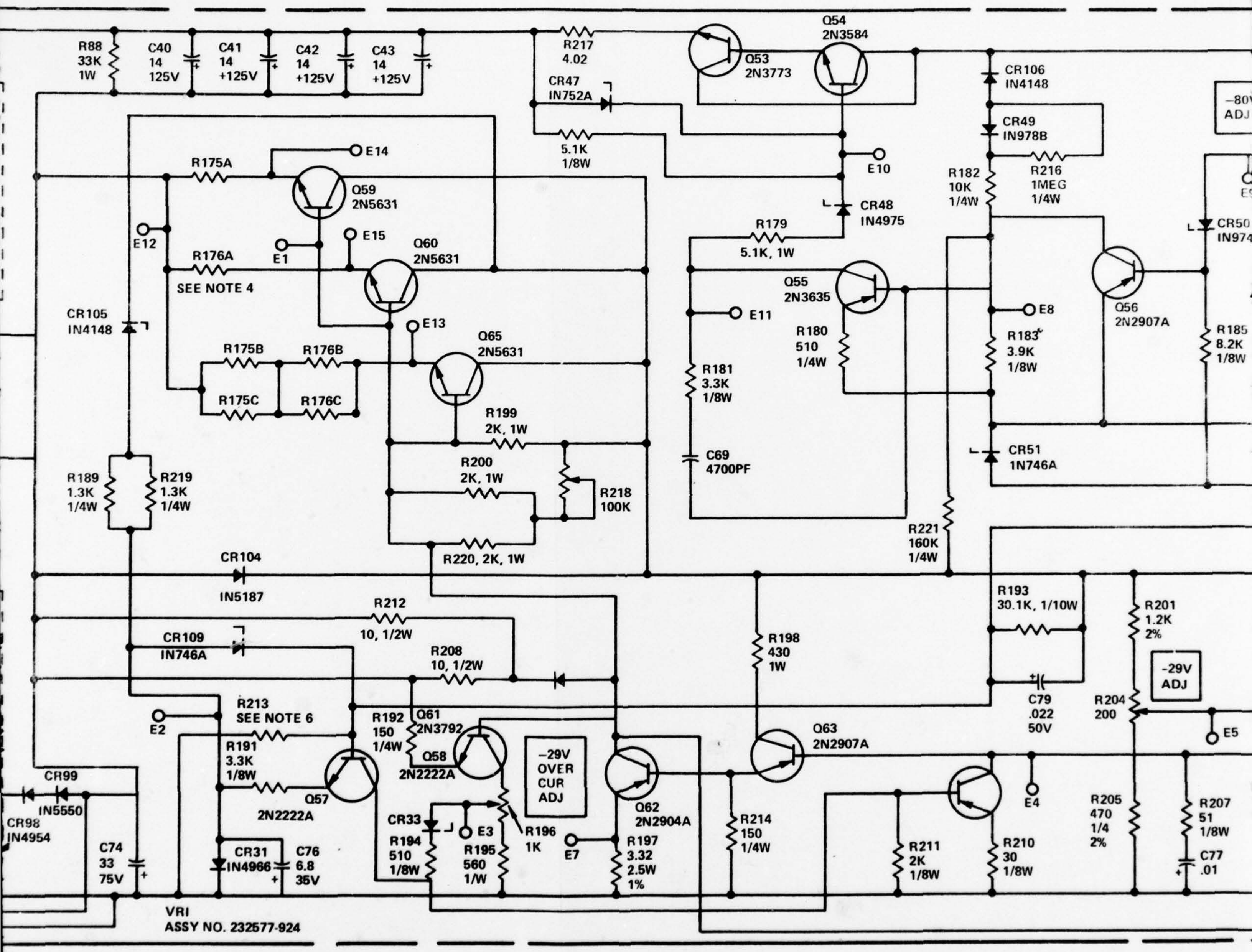
4. PART OF SPECIAL RESISTOR PACKAGE.

5. TERMINAL NUMBERING IS FOR REFERENCE ONLY AND DENOTES JUNCTION OF HARNESS AND PRINTED CIRCUIT BOARD.

6. SELECT AT TEST R213
   - 110K, 1/4W ± 2%
   - 150K, 1/4W ± 5%
   - 180K, 1/4W ± 5%
   - 220K, 1/4W ± 5%
   - 330K, 1/4W ± 5%
   - 430K, 1/4W ± 5%
   - 560K, 1/4W ± 5%
   - 680K, 1/4W ± 5%

7. C78 { 22 UF, 32V FOR EARLIER SYSTEMS
   33 UF, 75V FOR SYS EXH 023-UP (COPILOT) AND EXH 045-UP (T/S)




R88 33K 1W
C40 14 125V
C41 14 +125V
C42 14 +125V
C43 14 +125V
R217 4.02
CR47 IN752A
5.1K 1/8W
Q53 2N3773
Q54 2N3584
E10
CR48 IN4975
R179 5.1K, 1W
CR106 IN4148
CR49 IN978B
R216 1MEG 1/4W
R182 10K 1/4W
-80V ADJ
CR50 IN974
R175A
E14
Q59 2N5631
E12
E15
E1
Q60 2N5631
R176A
SEE NOTE 4
CR105 IN4148
E13
Q65 2N5631
R175B
R176B
R175C
R176C
R199 2K, 1W
R200 2K, 1W
R218 100K
R220, 2K, 1W
R189 1.3K 1/4W
R219 1.3K 1/4W
Q55 2N3635
E11
R180 510 1/4W
R181 3.3K 1/8W
C69 4700PF
E8
R183 3.9K 1/8W
Q56 2N2907A
R185 8.2K 1/8W
CR51 1N746A
R221 160K 1/4W
CR104 IN5187
R212 10, 1/2W
CR109 IN746A
R208 10, 1/2W
R198 430 1W
R193 30.1K, 1/10W
C79 .022 50V
R201 1.2K 2%
-29V ADJ
R204 200
E5
E2
R213 SEE NOTE 6
R191 3.3K 1/8W
Q57 2N2222A
R192 150 1/4W
Q61 2N3792
Q58 2N2222A
-29V OVER CUR ADJ
Q62 2N2904A
Q63 2N2907A
E4
CR99 IN5550
CR98 IN4954
C74 33 75V
CR31 IN4966
C76 6.8 35V
CR33
E3
R194 510 1/8W
R195 560 1/W
R196 1K
E7
R197 3.32 2.5W 1%
R214 150 1/4W
R211 2K 1/8W
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R207 51 1/8W
C77 .01
VRI
ASSY NO. 232577-924

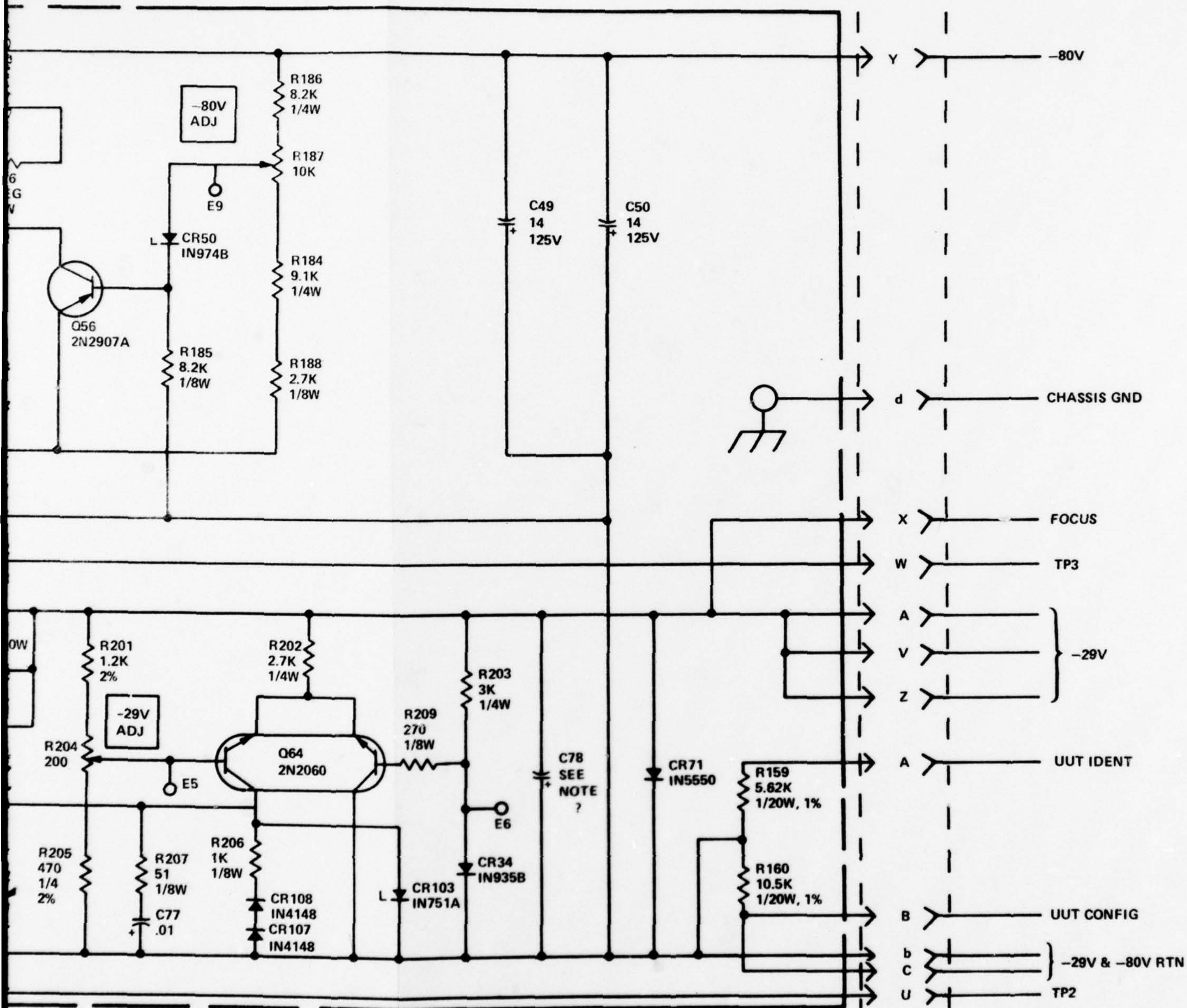
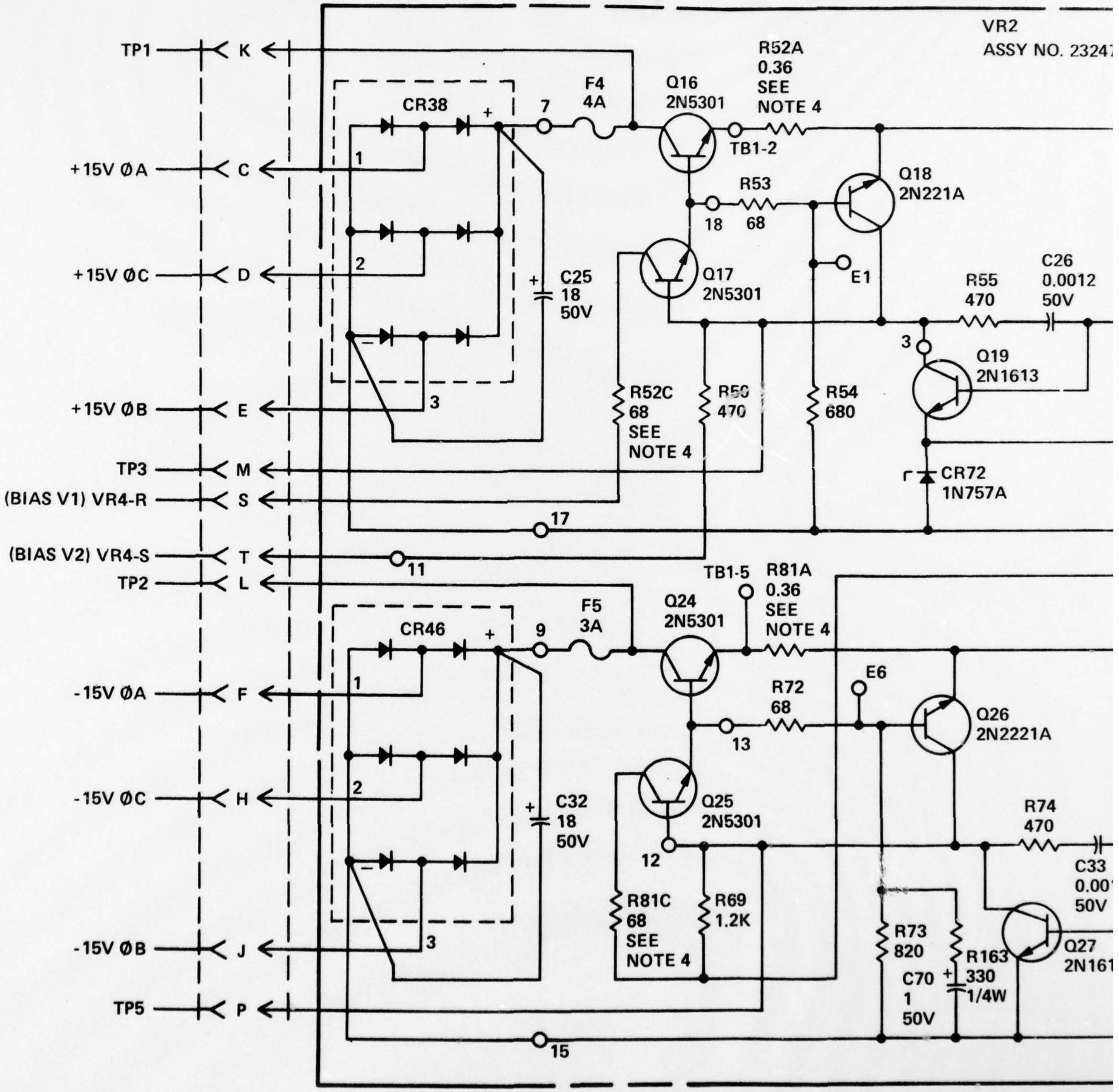


Figure 2-11. VR1 Power Supply


VR2
ASSY NO. 23247
TP1
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F
H
J
P
+15V ØA
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+15V ØB
TP3
(BIAS V1) VR4-R
(BIAS V2) VR4-S
TP2
-15V ØA
-15V ØC
-15V ØB
TP5
CR38
CR46
F4
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3A
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Q17
2N5301
Q18
2N221A
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Q25
2N5301
Q26
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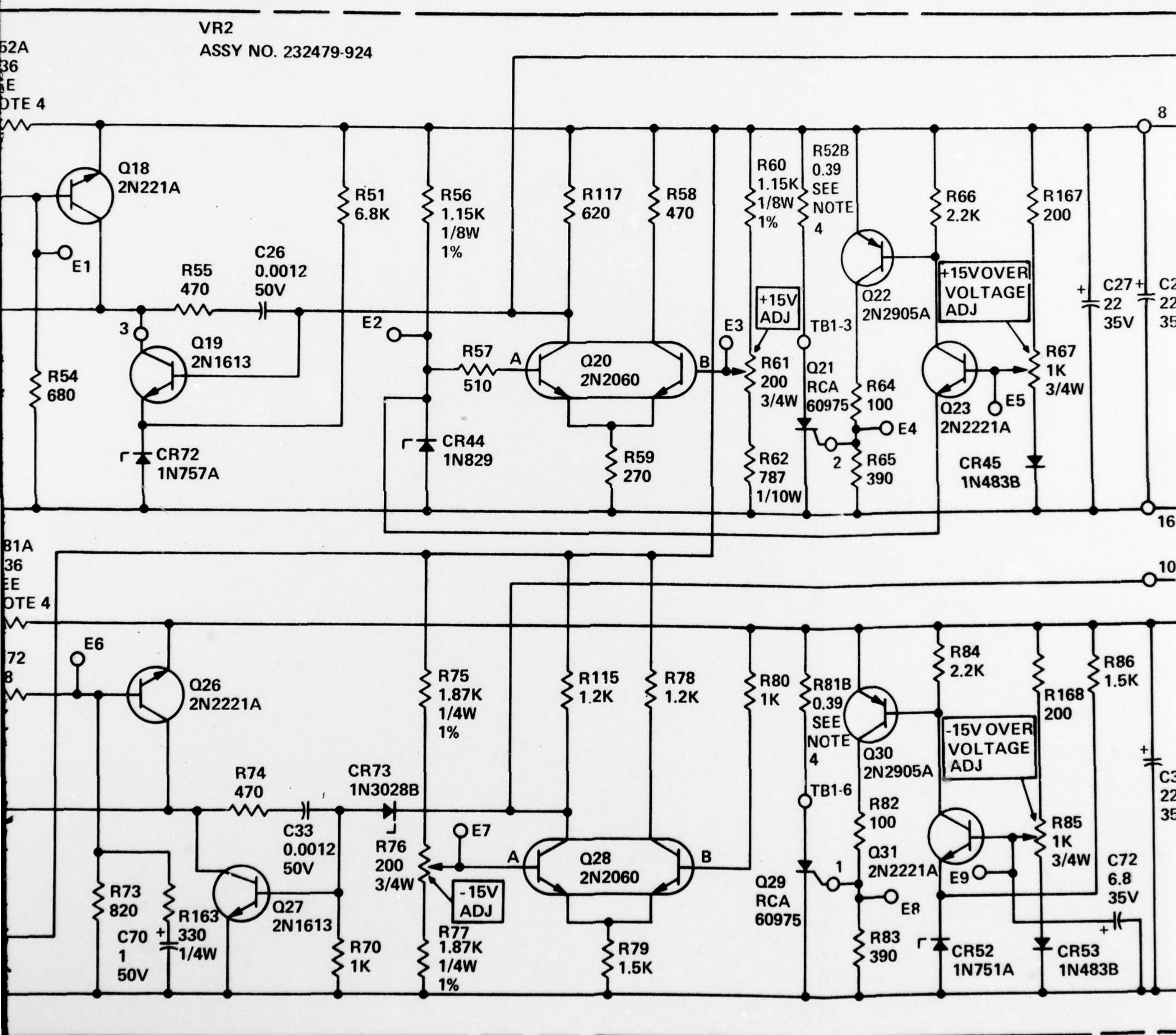
Q27
2N161
R52A
0.36
SEE
NOTE 4
TB1-2
R53
68
E1
C25
18
50V
R55
470
C26
0.0012
50V
R52C
68
SEE
NOTE 4
R50
470
R54
680
CR72
1N757A
TB1-5
R81A
0.36
SEE
NOTE 4
R72
68
E6
C32
18
50V
R74
470
C33
0.001
50V
R81C
68
SEE
NOTE 4
R69
1.2K
R73
820
R163
330
1/4W
C70
1
50V
1
2
3
7
9
11
12
13
15
17
18



VR2
ASSY NO. 232479-924
52A
36
EE
OTE 4
Q18
2N221A
E1
R55
470
C26
0.0012
50V
R51
6.8K
R56
1.15K
1/8W
1%
R117
620
R58
470
R60
1.15K
1/8W
1%
R52B
0.39
SEE
NOTE
4
R66
2.2K
R167
200
8
3
Q19
2N1613
R54
680
CR72
1N757A
E2
R57
510
A
Q20
2N2060
B
E3
+15V
ADJ
R61
200
3/4W
TB1-3
Q21
RCA
60975
Q22
2N2905A
+15V OVER
VOLTAGE
ADJ
C27
22
35V
C2
22
35
CR44
1N829
R59
270
R62
787
1/10W
R64
100
E4
2
R65
390
Q23
2N2221A
E5
R67
1K
3/4W
CR45
1N483B
16
81A
36
EE
OTE 4
10
72
8
E6
Q26
2N2221A
R75
1.87K
1/4W
1%
R115
1.2K
R78
1.2K
R80
1K
R81B
0.39
SEE
NOTE
4
Q30
2N2905A
R84
2.2K
R168
200
R86
1.5K
-15V OVER
VOLTAGE
ADJ
C3
22
35
R74
470
CR73
1N3028B
C33
0.0012
50V
E7
R76
200
3/4W
-15V
ADJ
A
Q28
2N2060
B
TB1-6
R82
100
Q31
2N2221A
R85
1K
3/4W
C72
6.8
35V
E9
1
Q29
RCA
60975
E8
R73
820
R163
330
1/4W
C70
1
50V
Q27
2N1613
R70
1K
R77
1.87K
1/4W
1%
R79
1.5K
R83
390
CR52
1N751A
CR53
1N483B

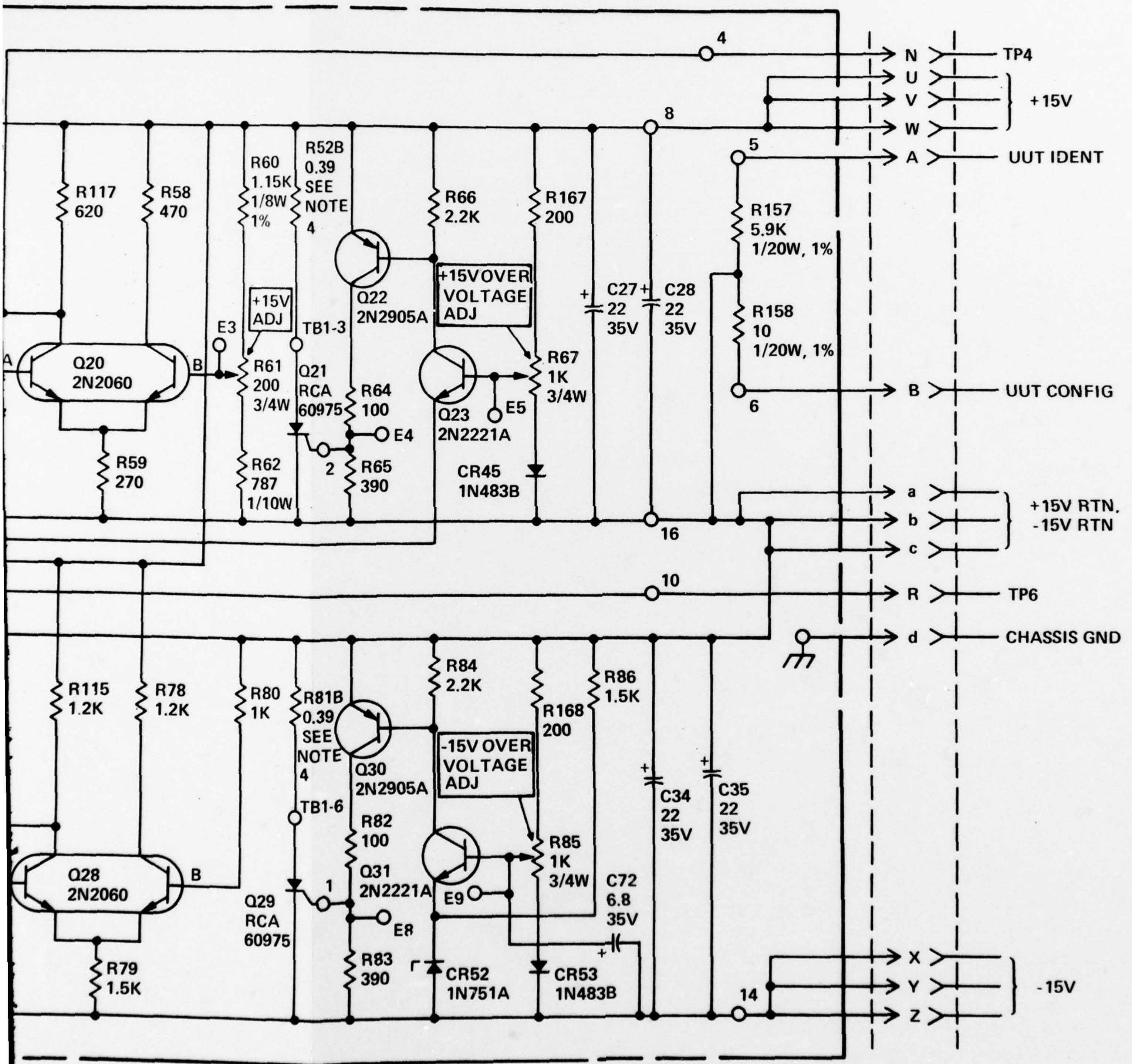
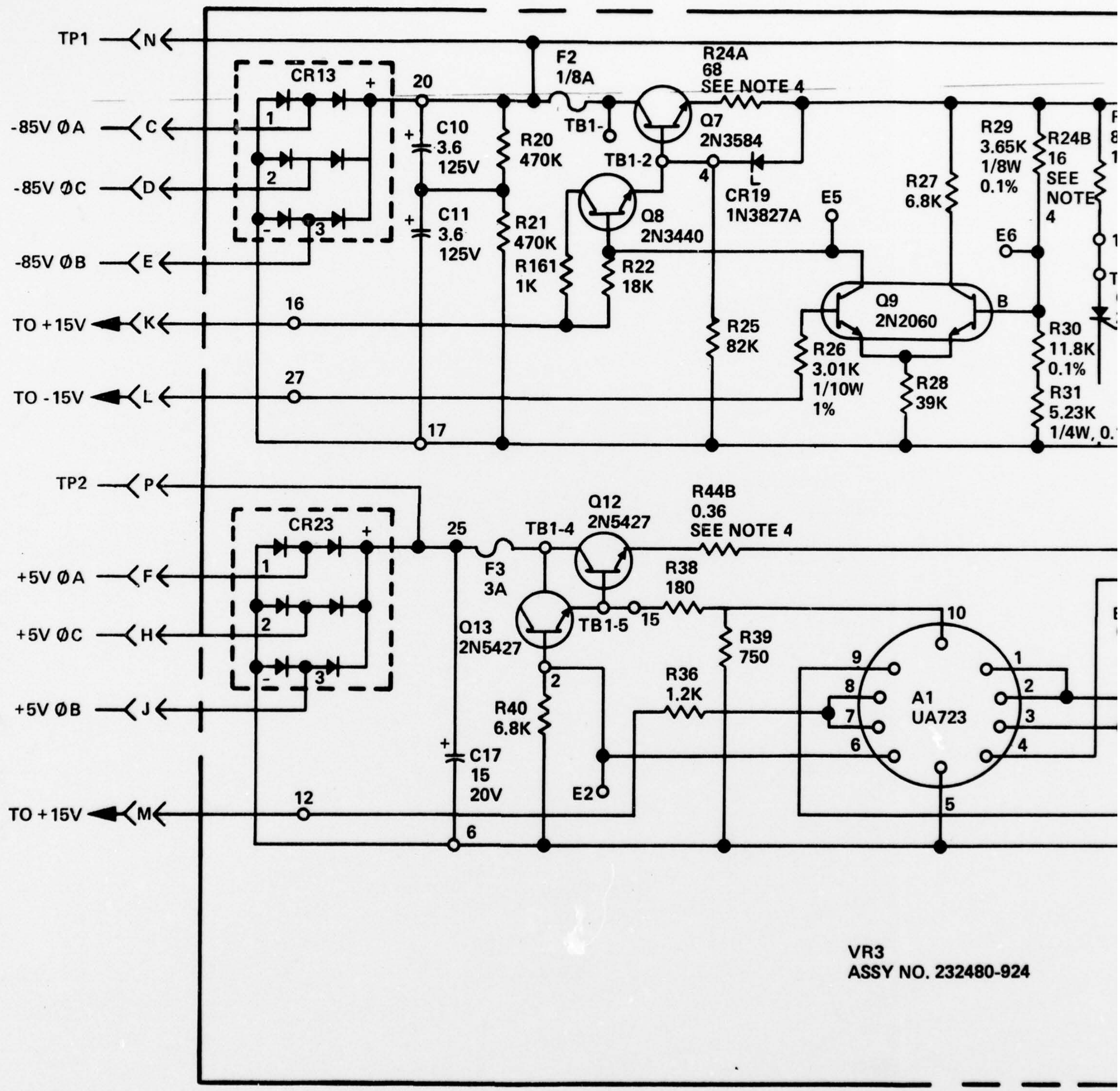
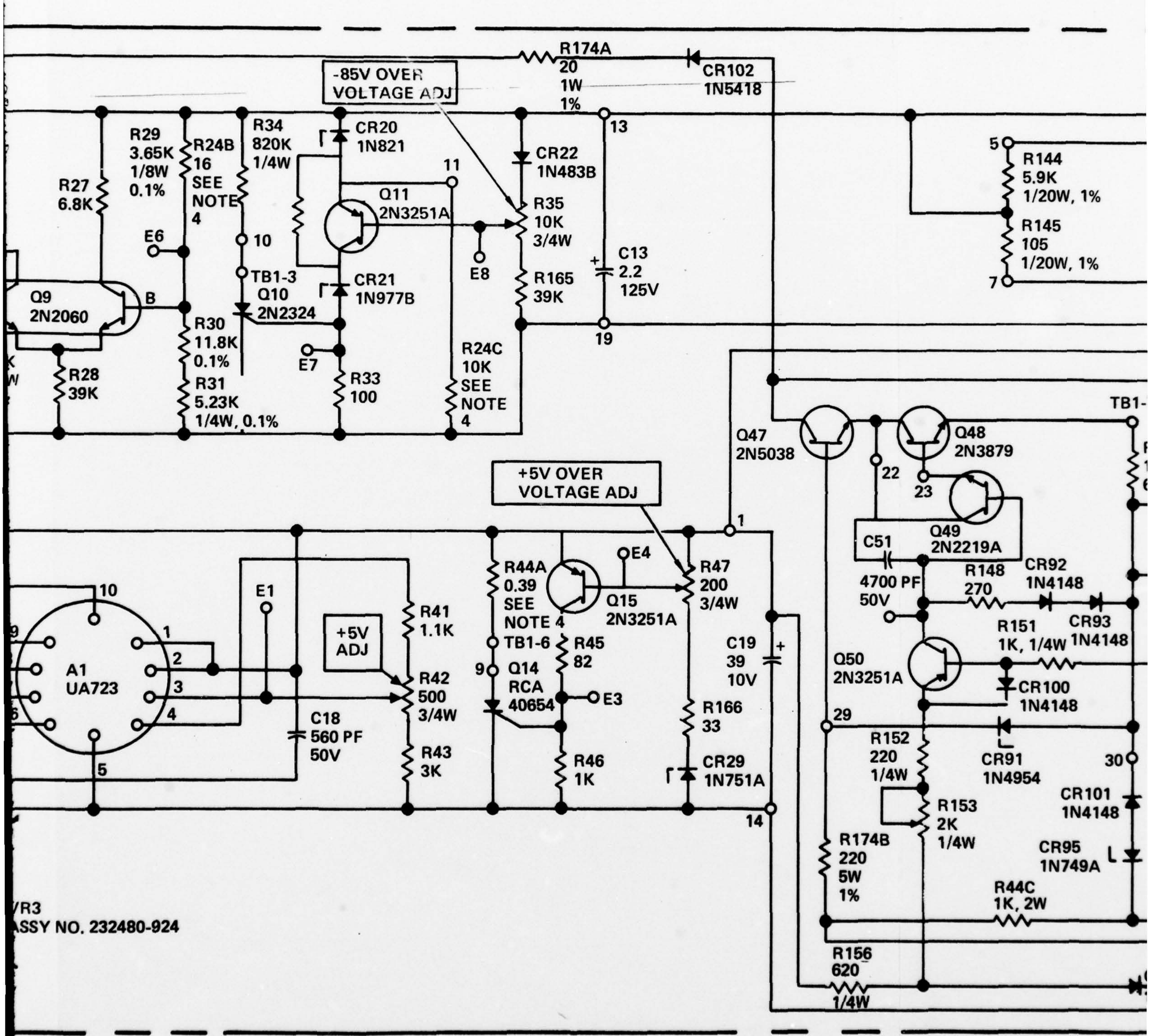


Figure 2-12. VR2 Power Supply

3


TP1
N
-85V ØA
C
-85V ØC
D
-85V ØB
E
TO +15V
K
TO -15V
L
TP2
P
+5V ØA
F
+5V ØC
H
+5V ØB
J
TO +15V
M
CR13
CR23
20
17
16
27
25
12
6
C10 3.6 125V
C11 3.6 125V
R20 470K
R21 470K
R161 1K
R22 18K
F2 1/8A
TB1-
TB1-2
R24A 68 SEE NOTE 4
Q7 2N3584
Q8 2N3440
CR19 1N3827A
E5
R25 82K
R26 3.01K 1/10W 1%
Q9 2N2060
R28 39K
R27 6.8K
R29 3.65K 1/8W 0.1%
R24B 16 SEE NOTE 4
E6
B
R30 11.8K 0.1%
R31 5.23K 1/4W, 0.
F3 3A
TB1-4
Q12 2N5427
R44B 0.36 SEE NOTE 4
Q13 2N5427
TB1-5
R38 180
15
R39 750
R36 1.2K
R40 6.8K
C17 15 20V
E2
A1 UA723
10
VR3
ASSY NO. 232480-924



-85V OVER VOLTAGE ADJ
R174A 20 1W 1%
CR102 1N5418
R29 3.65K 1/8W 0.1%
R24B 16 SEE NOTE 4
R34 820K 1/4W
CR20 1N821
CR22 1N483B
R27 6.8K
Q11 2N3251A
R35 10K 3/4W
C13 2.2 125V
R144 5.9K 1/20W, 1%
R145 105 1/20W, 1%
E6
E8
CR21 1N977B
R165 39K
TB1-3
Q10 2N2324
Q9 2N2060
R30 11.8K 0.1%
R31 5.23K 1/4W, 0.1%
R28 39K
E7
R33 100
R24C 10K SEE NOTE 4
Q47 2N5038
Q48 2N3879
Q49 2N2219A
+5V OVER VOLTAGE ADJ
C51 4700 PF 50V
R148 270
CR92 1N4148
CR93 1N4148
A1 UA723
E1
+5V ADJ
R41 1.1K
R42 500 3/4W
R43 3K
C18 560 PF 50V
R44A 0.39 SEE NOTE 4
TB1-6
Q14 RCA 40654
R45 82
E3
R46 1K
Q15 2N3251A
E4
R47 200 3/4W
R166 33
CR29 1N751A
C19 39 10V
Q50 2N3251A
R151 1K, 1/4W
CR100 1N4148
CR91 1N4954
R152 220 1/4W
R153 2K 1/4W
CR101 1N4148
CR95 1N749A
R174B 220 5W 1%
R44C 1K, 2W
R156 620 1/4W
TB1-
/R3
ASSY NO. 232480-924

7

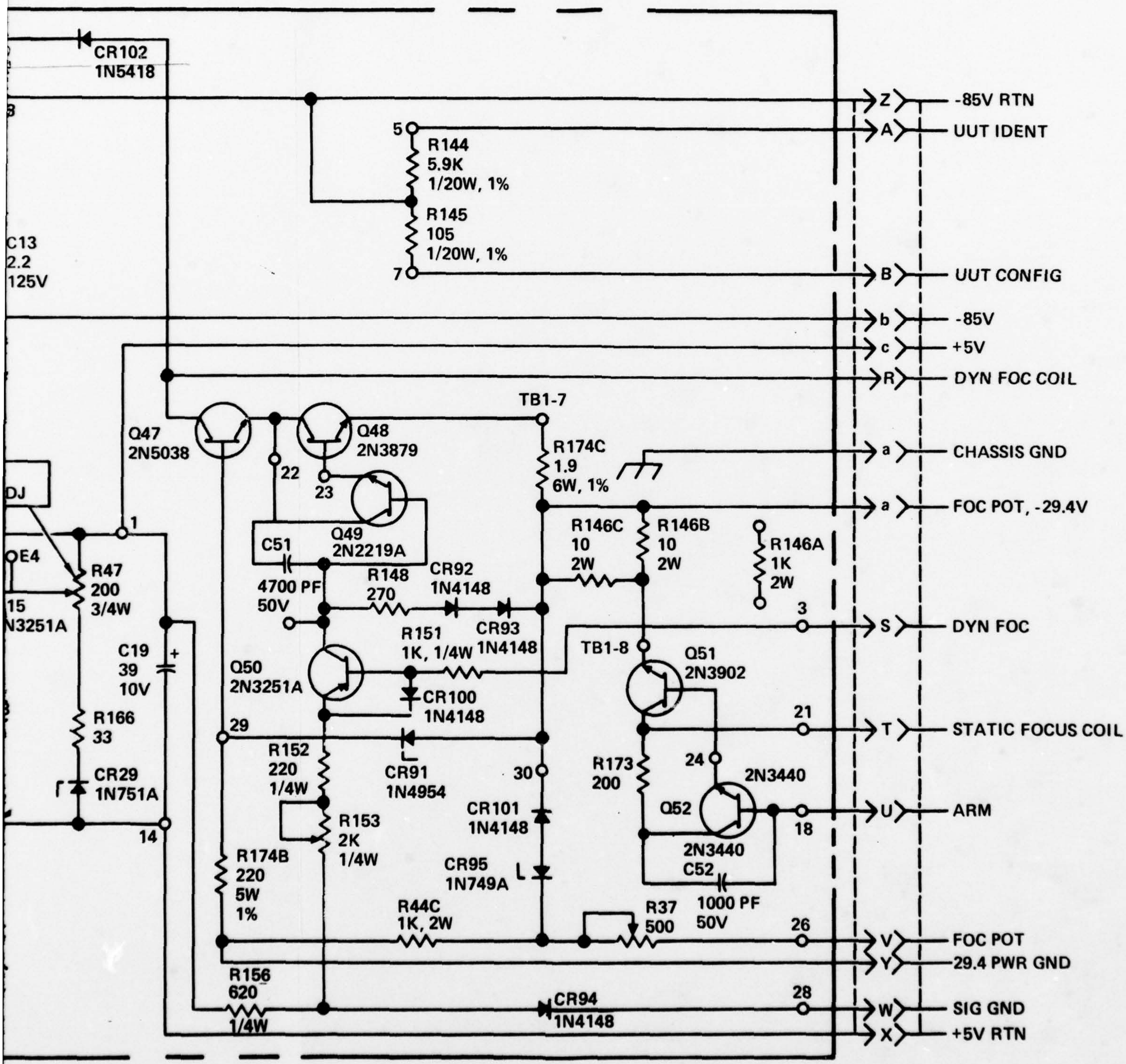
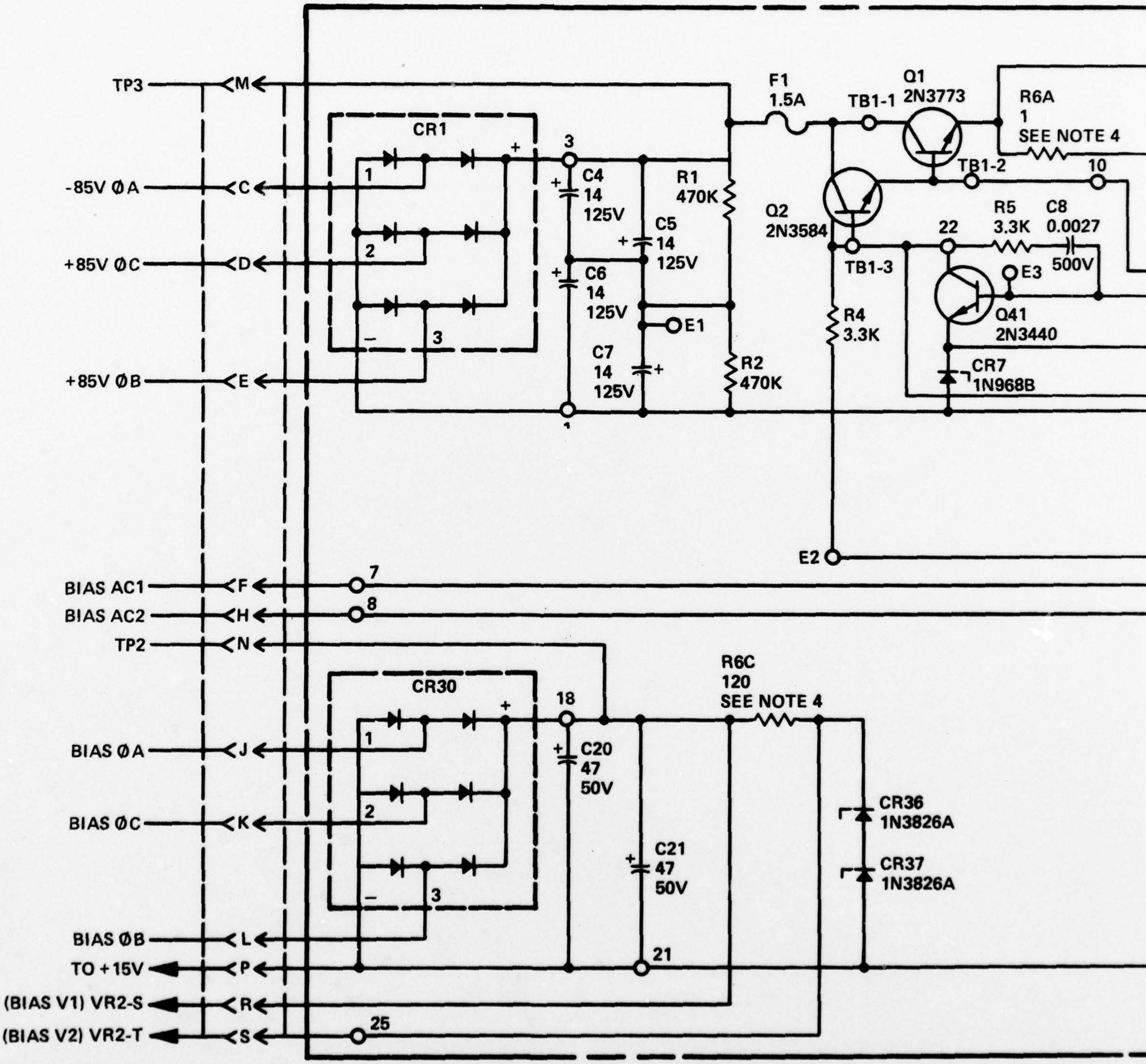
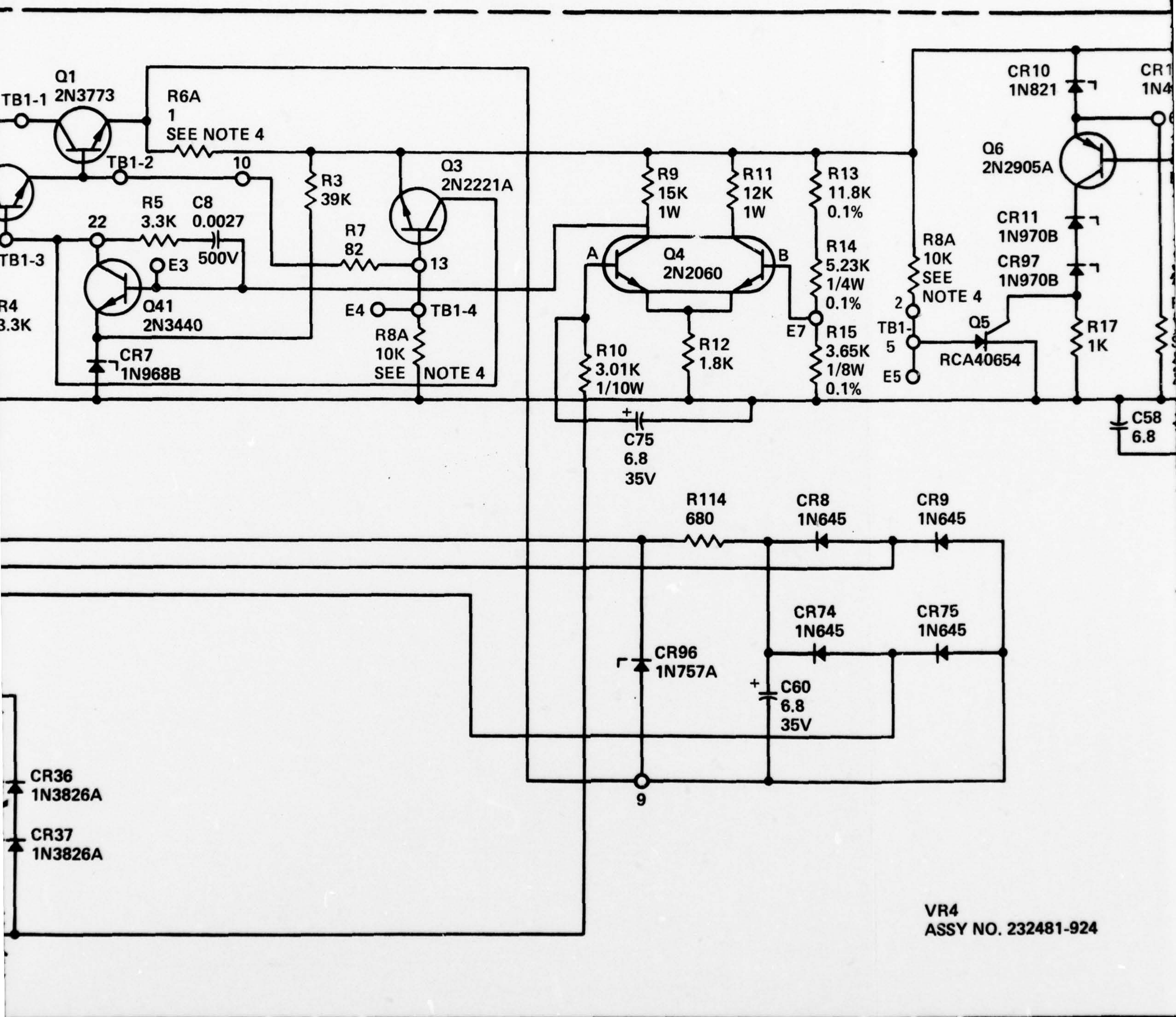


Figure 2-13. VR3 Power Supply

3


TP3
M
-85V ØA
C
+85V ØC
D
+85V ØB
E
CR1
1
2
3
+
−
3
C4
14
125V
C5
14
125V
C6
14
125V
C7
14
125V
E1
1
R1
470K
R2
470K
F1
1.5A
TB1-1
Q1
2N3773
R6A
1
SEE NOTE 4
TB1-2
10
Q2
2N3584
TB1-3
22
R5
3.3K
C8
0.0027
500V
E3
Q41
2N3440
R4
3.3K
CR7
1N968B
E2
BIAS AC1
F
7
BIAS AC2
H
8
TP2
N
CR30
18
R6C
120
SEE NOTE 4
BIAS ØA
J
BIAS ØC
K
C20
47
50V
C21
47
50V
CR36
1N3826A
CR37
1N3826A
BIAS ØB
L
TO +15V
P
21
(BIAS V1) VR2-S
R
(BIAS V2) VR2-T
S
25


Q1
2N3773
TB1-1
TB1-2
TB1-3
R6A
1
SEE NOTE 4
10
R3
39K
Q3
2N2221A
22
R5
3.3K
C8
0.0027
500V
R7
82
13
E3
R4
3.3K
Q41
2N3440
E4
TB1-4
R8A
10K
SEE
NOTE 4
CR7
1N968B
R9
15K
1W
R11
12K
1W
R13
11.8K
0.1%
A
Q4
2N2060
B
R14
5.23K
1/4W
0.1%
E7
R15
3.65K
1/8W
0.1%
R10
3.01K
1/10W
R12
1.8K
C75
6.8
35V
R8A
10K
SEE
NOTE 4
2
TB1-
5
E5
Q5
RCA40654
CR10
1N821
Q6
2N2905A
CR11
1N970B
CR97
1N970B
R17
1K
C58
6.8
R114
680
CR8
1N645
CR9
1N645
CR74
1N645
CR75
1N645
CR96
1N757A
C60
6.8
35V
9
CR36
1N3826A
CR37
1N3826A
VR4
ASSY NO. 232481-924

LR 28780

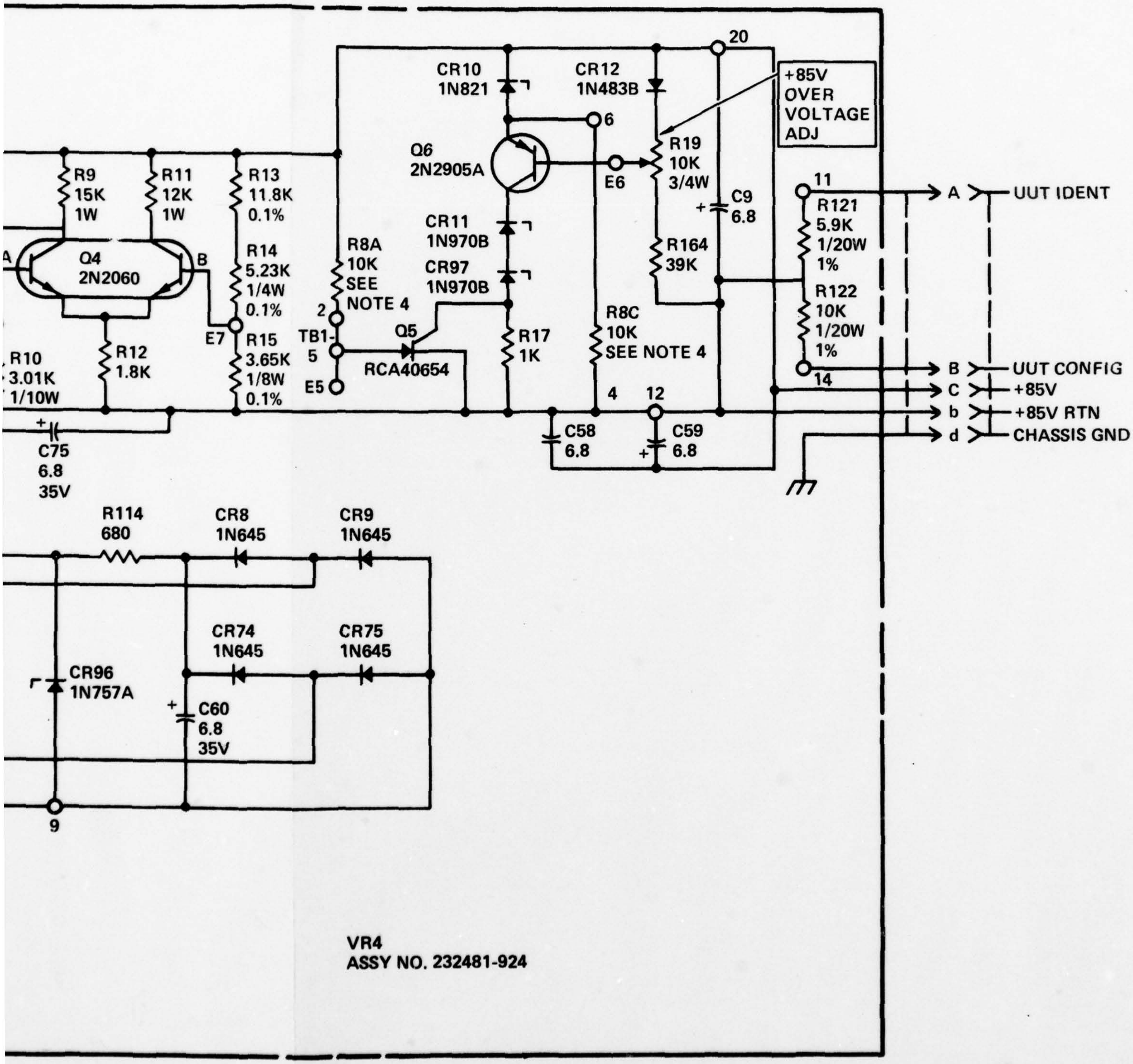


Figure 2-14. VR4 Power Supply

7

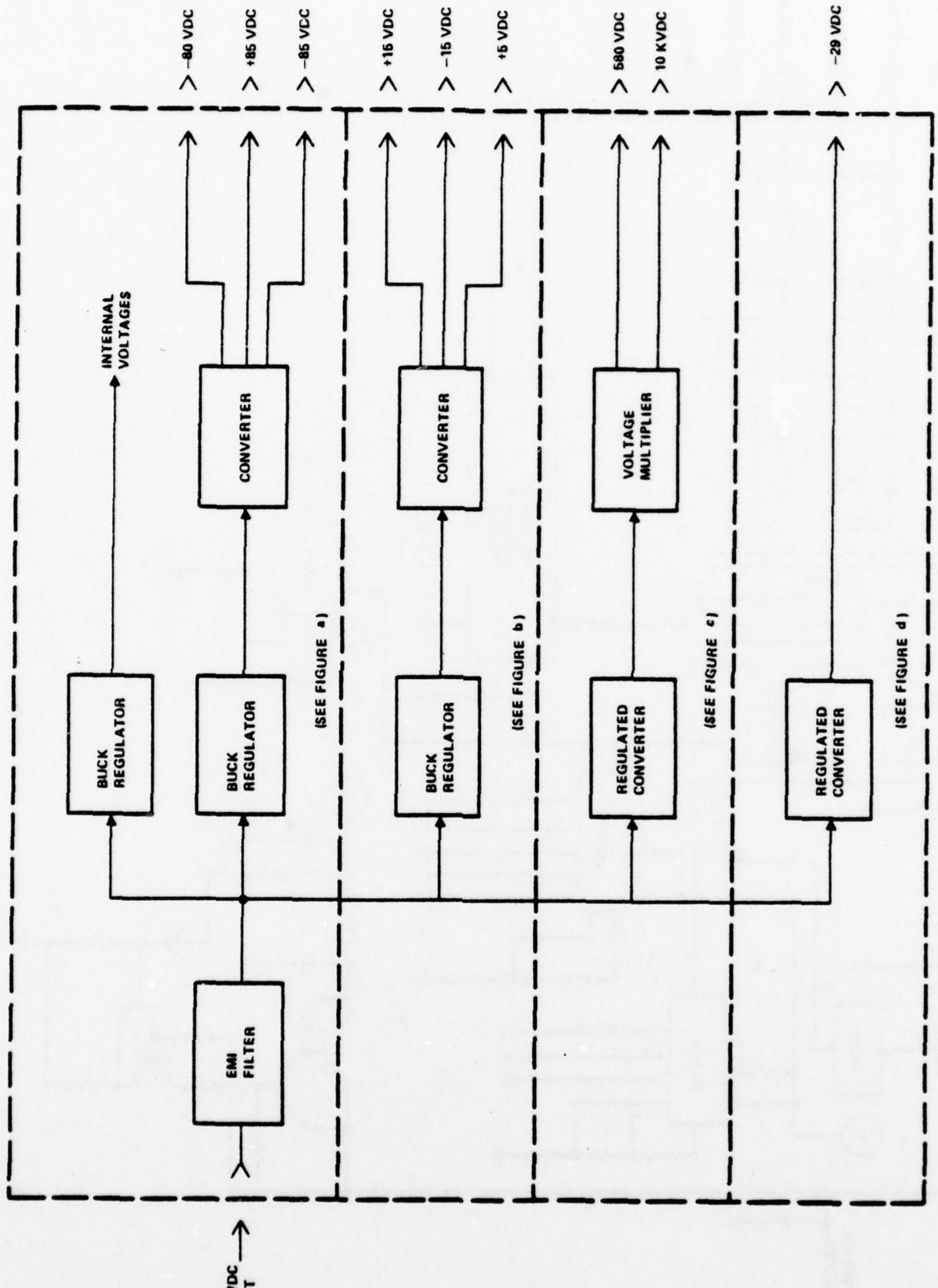


Figure 15. 270 Vdc Power Supply

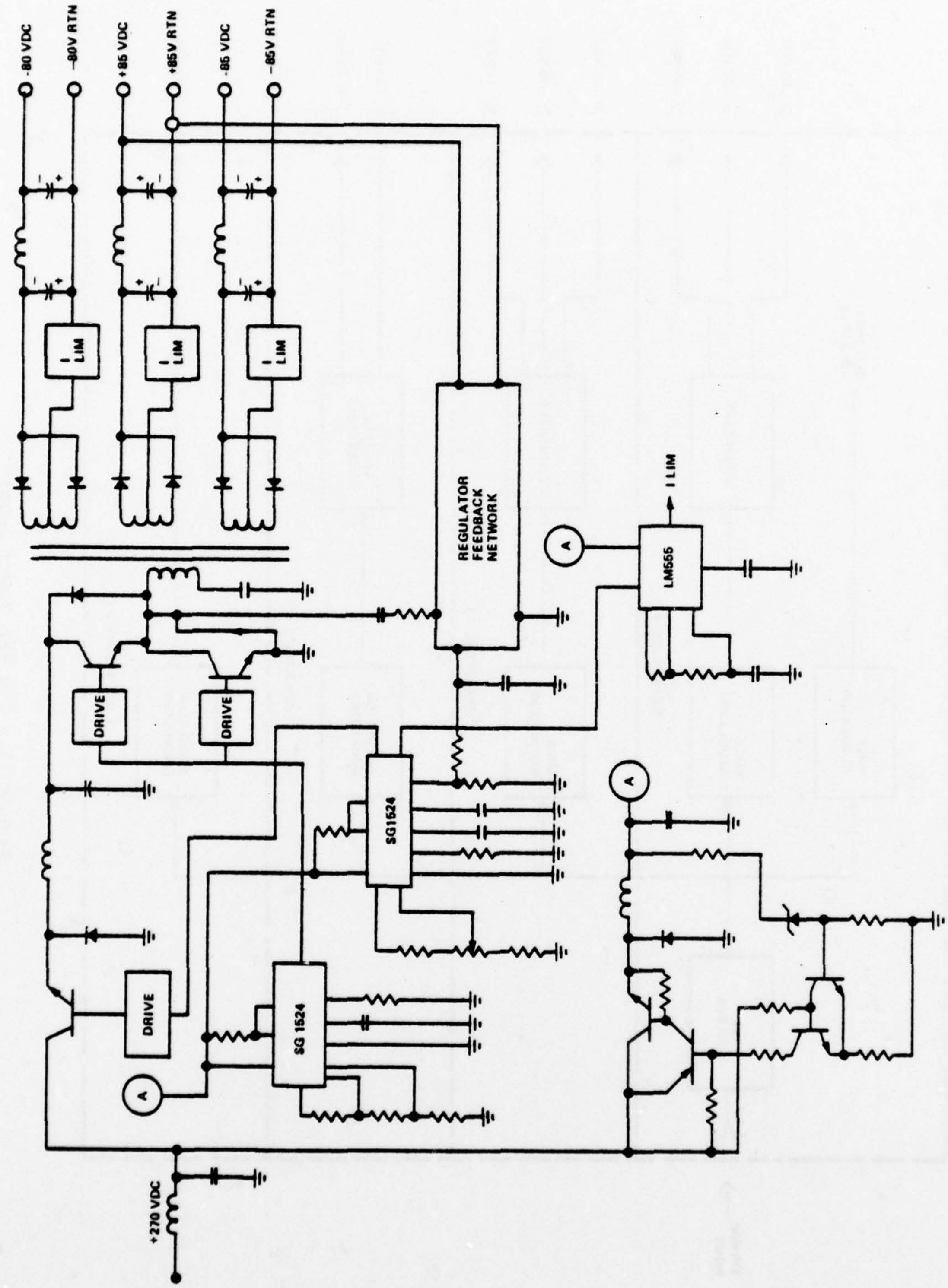


Figure 15a. ±85/-80 Vdc Power Supply

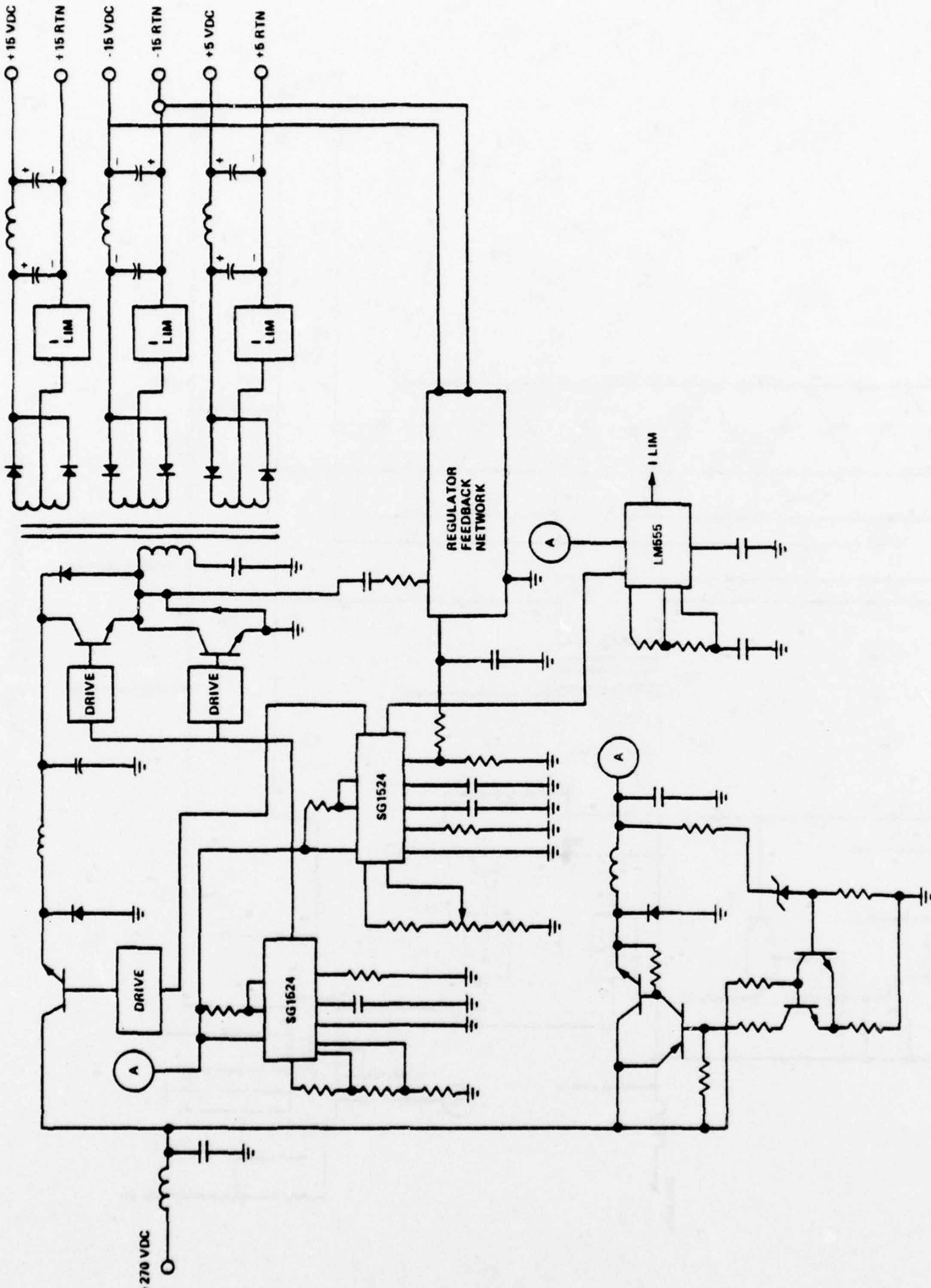


Figure 15b. ±15/+5 Vdc Power Supply

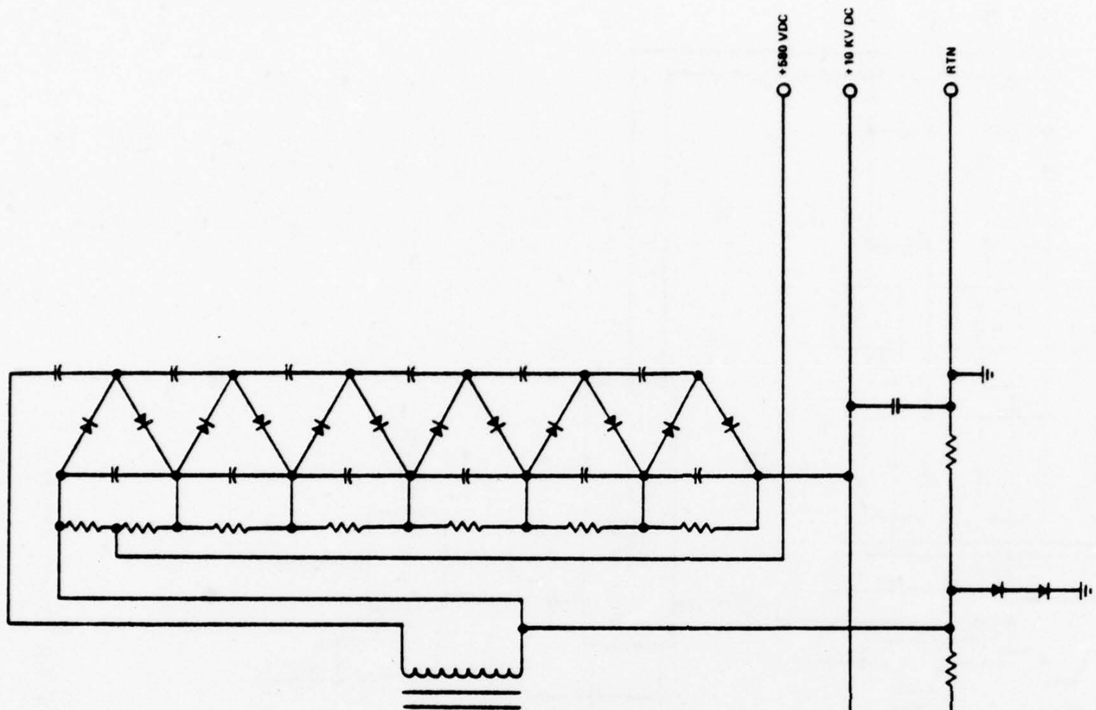


Figure 15c. High Voltage Power Supply

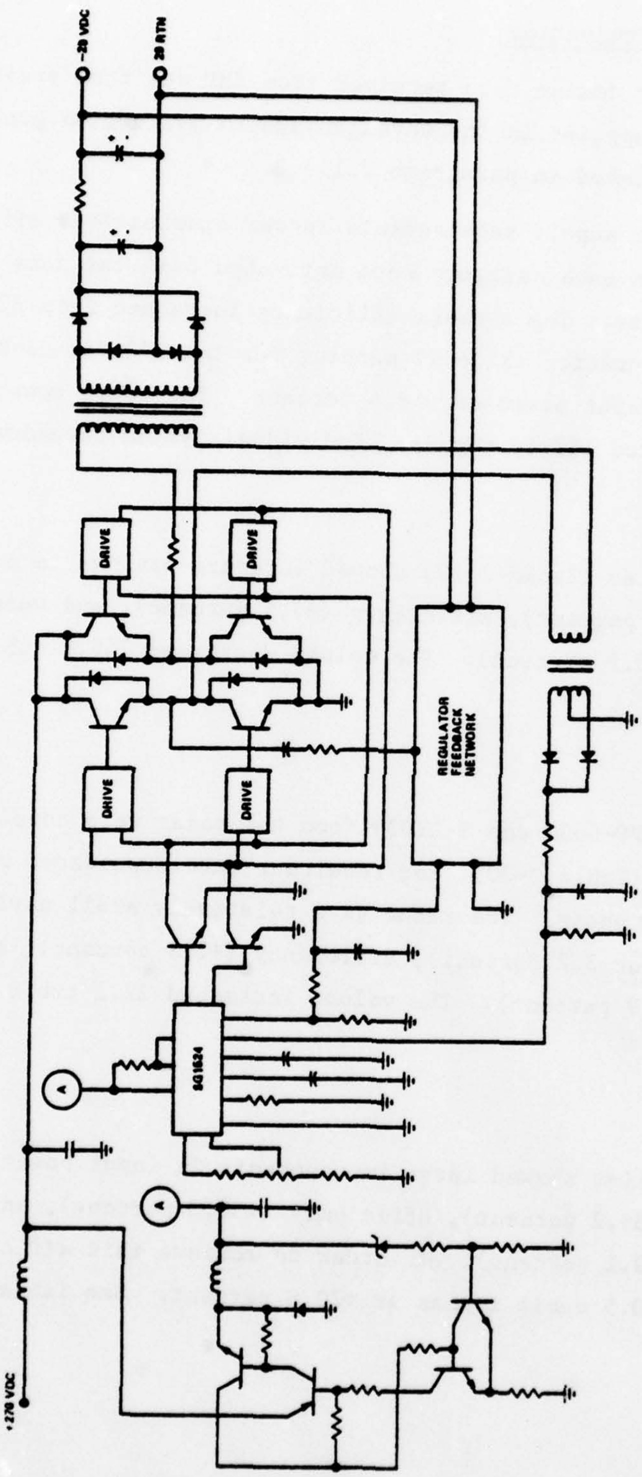


Figure 15d. -29 Vdc Power Supply

2.1.5.7 Study Group Projection

The 270 Vdc power design data received from EMD was then projected across the remaining power supplies in the seven subsystem evaluation group based on the categories established in paragraph 2.1.5.3.

The 270 Vdc power supply requirements (power dissipation, efficiency, weight, and volume) in each category were estimated from the data by EMD on the evaluation units. The average efficiency increased from 62.65 percent for the 400 Hz configuration to 76.77 percent for the 270 Vdc configuration, for a net change in input power of -18.4 percent. The total power supply module weight decreased 162.64 pounds. Individual system breakdowns are:

OL-82 (ADP)

ADP power supplies (Table 2-19) showed moderate savings in power (-417.2 watts or 9.9 percent), efficiency (+7.5 percent), and weight (-35.78 pounds or -36.1 percent). The volume decreased 745.3 cubic inches or 33 percent.

APS-116 (Radar)

Only two WRAs (PP-6633 and T-1203) from the radar were considered in this phase of study (Table 2-20), the remainder were considered during the parametric evaluation phase. The radar gave relatively small savings in power (-120.2 watts or 3.2 percent), efficiency (+2.8 percent), and weight (-6.02 pounds or 17.9 percent). The volume increased 22.1 cubic inches or 3.18 percent.

ASA-82 (TDS)

TDS power supplies showed large improvements in input power (-1082.2 watts or -35.2 percent), efficiency (+30.3 percent), and weight (-26.5 pounds or -39.1 percent). In order to achieve this efficiency, the volume increased 160.5 cubic inches or +20.8 percent. See Table 2-21.

TABLE 2-19. OL-82A/AYS

		400 HZ					270 VDC					
	P/N	PWR_{IN}	PWR_{OUT}	EFF.	WEIGHT	VOLUME	PWR_{IN}	PWR_{OUT}	EFF.	ΔPWR	WEIGHT	VOLUME
Sig. Data Conv. CV-2882A (WRA1)	1022401											
A31	1023782	542.5	415.0	76.50%	7.3	115						
A33	1026390	9.0	6.2	68.89%	0.42	13						
A34	1026389	18.5	12.8	69.08%	0.40	13						
TOTAL		542.5	406.5	74.93%	8.12	141	503	406.5	80.81%	-39.5	7.67	160
Sig. Data Conv. CV-2882A (WRA2)	102401											
A31	1023782	542.5	415.0	76.50%	7.3	115						
A33	1026390	9.0	6.2	68.89%	0.42	13						
A34	1026389	18.5	12.8	69.08%	0.40	13						
TOTAL		542.5	406.5	74.93%	8.12	141	503	406.5	80.81%	-39.5	7.67	160
Sig. Gen. SG-962A (WRA3)	022403											
A38	1023771	568	386	67.96%	7.4	115						
A40	1023358	122	73.2	60.00%	1.22	14						
A41	1026390	20.5	14	68.29%	0.42	13						
A42	1026389	23	15	65.22%	0.40	13						
TOTAL		733.5	488.2	66.56%	9.44	155	656	488.2	74.42%	-77.5	9.0	195.1

TABLE 2-19. OL-82A/AYS (Continued)

		400 HZ					270 VDC					
	P/N	PWR_{IN}	PWR_{OUT}	EFF.	WEIGHT	VOLUME	PWR_{IN}	PWR_{OUT}	EFF.	ΔPWR	WEIGHT	VOLUME
Spect. Anal. CV-2883A (WRA4)	1022404											
A38	1023771	562	394	70.11%	6.18	96						
A40	1023358	122	73.2	60.00%	1.22	14						
A41	1026390	20.5	14	68.29%	0.42	13						
A42	1026389	23	15	65.22%	0.40	13						
TOTAL		727.5	496.2	68.21%	8.22	136	657.8	496.2	75.43%	-69.7	7.84	169.6
Comp, Sonar Data CP-1140A (WRA5)	1022409											
A42	1023771	534	390	73.03%	7.4	115						
A44	1026390	27	15.6	57.78%	0.42	13						
A45	1026389	21	13	61.91%	0.40	13						
TOTAL		582	418.6	71.92%	8.22	141	552	418.6	75.83%	-30.5	6.4	139.5
Comp, Sonar Data CP-1140A (WRA6)	1022409											
A42	1023771	534	390	73.03%	7.4	115						
A44	1026390	27	15.6	57.78%	0.42	13						
A45	1026389	21	13	61.91%	0.40	13						
TOTAL		582	418.6	71.92%	8.22	141	552	418.6	75.83%	-30.5	6.4	139.5
Drum P/S PP-6671 (WRA11)	621600-4											
P/S 1		341	204.5	59.97%	24.35	700						
P/S 2		341	204.5	59.97%	24.35	700						
TOTAL		682	409	59.97%	48.7	1400	552	409	74.09%	-130	18.3	546
SUBSYSTEM TOTAL		4209	2860.5	67.96%	99.04	2255	3791.8	2860.5	75.44%	-417.2	63.28	1509.7

TABLE 2-20. APS 116 RADAR

	400 Hz					270 VDC					
	Pwr_{In}	Pwr_{Out}	Eff	Weight	Volume	Pwr_{In}	Pwr_{Out}	Eff	ΔPwr	Weight	Volume
Programmer/PS PP-6633											
718371	447	390	87.25%	5.4	224						
718403/718374	192	140	72.92%	1.13	78						
718372	480	427.5	89.06%	5.9	224						
Total	927	702.5	75.73%	12.43	526	880.7	702.0	79.71%	46.3	11.36	483.9
Transmitter T-1203											
715335-1	231.3	167.45	72.39%	2.57	33.7						
HVPC	2606	2319	88.99%	18.32	124.3						
715383-1	2.7	0.3	11.11%	0.36	9.6						
Total	2840.0	2486.75	87.56%	21.25	167.6	2766.1	2486.75	89.90%	73.9	16.3	231.8
Radar Set Control C-8788											
711741	167	108	64.67%								
Sig Data Conv Str CV-2852						Part of Parametric Evaluation					
711843	162	151.7	93.64%	2.81							
711824	87.7	50	57.01%	1.12							
711658	64	35	54.69%	1.37							
711657	38.5	23	59.74%	2.52							
Total	162	69.5	42.90%	7.82							

TABLE 2-21. ASA-82

		400 HZ					270 VDC					
	P/N	PWR_{IN}	PWR_{OUT}	Eff.	Weight	Volume	PWR_{IN}	PWR_{OUT}	Eff.	ΔPWR	Weight	Volume
Pilot display IP-1051	231502-000											
XFMR	226686-000	437	417.8	95.61%	5.5	39.4						
VR4	232011-924	43.3	30.3	69.98%	0.65	14.7						
VR2	232477-924	52.9	28.4	53.69%	0.7	14.7						
VR3	232478-924	56.3	26.4	46.89%	0.75	14.7						
VR1	232555-924	265.3	169.8	64.00%	0.78	14.7						
HVPS	226179-000	23.4	10.1	43.16%	2.25	16.0						
Total		437	241.6	55.29%	10.63	114.2	285.8	241.6	84.54%	-151.2	5.41	146.8
Co-pilot display IP-1053	231503-924											
XFMR	226685-000	552	524.4	95.00%	5.75	41.95						
VR1	232577-924	310	228.1	73.58%	1.062	14.7						
VR3	232480-924	37.8	14.3	37.83%	0.80	14.7						
VR2	232479-924	95.3	51	53.52%	0.812	14.7						
VR4	232481-924	81.3	54.8	67.41%	0.812	14.7						
HVPS	26179-000	23.4	10.1	43.16%	2.25	16.0						
Total		552	334.9	60.67%	11.49	116.8	377	334.9	88.83%	-175	7.15	146.8
ARU IP-1052	231560-924											
XFMR	226292-000	263	245.8	93.46%	5.75	41.95						
VR1	232482-913	40.3	25.6	63.52%	0.718	14.7						
VR2	232483-917	53.6	28.7	53.55%	0.69	14.7						
VR3	232484-909	34.6	12.6	36.42%	0.625	14.7						
VR4	232485-909	71.5	61.1	85.46%	0.75	14.7						
VR5	232554-924	45.8	29.3	63.97%	0.468	14.7						
HVPS	226179-000	23.4	10.1	43.16%	2.25	16.0						
Total		263	144	54.75%	11.25	131.5	168	144	85.71%	-95	4.34	165.4

TABLE 2-21. ASA-82 (Continued)

		400 HZ					270 VDC					
	P/N	PWR_{IN}	PWR_{OUT}	Eff.	Weight	Volume	PWR_{IN}	PWR_{OUT}	Eff.	ΔPWR	Weight	Volume
TACCO/SENSO IP-1054	231504-924											
XFMR	226685-000	577	548.4	95.04%	5.75	41.95						
VR1	232577-924	324.4	238.3	73.46%	1.062	14.7						
VR3	232480-924	39.5	15.0	37.98%	0.80	14.7						
VR2	232479-924	99.6	53.3	53.51%	0.812	14.7						
VR4	232481-924	84.9	57.2	67.37%	0.812	14.7						
HVPS	236179-000	23.4	10.1	43.16%	2.25	16.0						
Total (X2)		577	350.5	60.75%	11.49	116.8	395	350.5	88.73%	-182	7.49	146.8
DGU CV-2806	231507-924											
XFMR	226245-000	672	612.2	92.44%	3.9	25.5						
VR1	231909-924	74.1	38.2	51.55%	0.562	12.4						
VR2	231911-924	13.7	7.1	51.82%	0.75	12.4						
VR3	231910-924	67.5	29.7	44.00%	0.53	12.4						
VR4	231909-924	74.1	38.2	51.55%	0.562	12.4						
VR5	231911-924	13.7	7.1	51.82%	0.75	12.4						
VR6	231910-924	67.5	29.7	44.00%	0.53	12.4						
VR7	231909-924	74.1	38.2	51.55%	0.562	12.4						
VR8	231911-924	13.7	7.1	51.82%	0.75	12.4						
VR9	231910-924	67.5	29.7	44.00%	0.530	12.4						
VR10	231909-924	74.1	38.2	51.55%	0.562	12.4						
VR11	231911-924	13.7	7.1	51.82%	0.75	12.4						
VR12	231910-924	67.5	29.7	44.00%	0.53	12.4						
Totals		672	300	44.64%	11.27	174.3	375	300	80.00%	-297	7.12	178.
SUBSYSTEM TOTALS		3078	1721.5	55.93%	67.62	770.4	1995.8	1721.5	86.26%	-1082.2	41.16	930.9

ARC-153 (HF Radio)

HF radio power supplies showed moderately large improvement in input power (-464.4 watts or -20.4 percent), efficiency (+12.4 percent), and weight (-14.8 pounds or -33.5 percent). The change in volume was less significant at -51.2 cubic inches or -13.3 percent. See Table 2-22.

OR-89 (FLIR)

FLIR power supplies showed moderate improvement in input power (-301.8 watts or -11.4 percent), efficiency (+8.8 percent), and weight (-13.83 pounds or -40.8 percent). The volume increased 51.9 cubic inches or 11 percent. See Table 2-23.

AYK-10 (GPDC)

GPDC power supplies showed moderate improvement in input power (-223.8 watts or -12.0 percent) and efficiency (+8.5 percent), but the weight reduction (-36.22 pounds or -36.7 percent) was significant. The volume decreased 1249 cubic inches or 44.7 percent. See Table 2-24.

AYN-5 (AACS)

AACS power supplies showed little improvement in input power (-3.96 watts or 2.2 percent), efficiency (+1.6 percent) but once again there was a significant reduction in weight (-6.09 pounds or -66.8 percent). The volume decreased 81.5 cubic inches or -36.2 percent. See Table 2-25.

The module weight savings shown above does not give a complete picture of the total weight savings attainable. A percentage of total chassis weight is required to support power supply modules. (This includes mounting fixtures card cages, covers, etc.). In order to determine the chassis weight directly attributable to each power supply (Table 2-26), it was first necessary to establish chassis weight (W_c), total WRA weight ($W_{WRA\ I}$), and the weight of signal processing subassemblies (W_s), $W_s = W_{WRA\ I} - W_C$. (W_c and $W_{WRA\ I}$ were taken from the WRA configuration document D52601.100.) Next, the chassis weight per module weight (W_c/W_s) was computed. Once this ratio is

TABLE 2-22. ARC-153A

		400 Hz					270 Vdc					
	P/N	PWR_{IN}	PWR_{OUT}	EFF.	WEIGHT	VOLUME	PWR_{IN}	PWR_{OUT}	EFF	ΔPWR	WEIGHT	VOLUME
RF AMP. AM-6384	792-6422											
18V REG	797-3594	358.53	189.3	52.80%								
5/80V REG	797-3596	26.36	11.15	42.30%								
SCRN REG	797-3598	304.6	163.6	53.71%	23.1	282						
HV RECT	797-3597	1317.6	980	74.38%								
XFMRS		2230	2063.5	92.53%								
TOTAL		2230	1344.1	60.27%	39.3	282	1781.2	1293.9	72.64%	-448.8	28	496
HF R/T RT-1016	787-6568											
P/S	606-9378	87	36.8	42.30%	2.3	44.3						
ANT. COUPLER CU-1985	792-6239											
P/S	790-2799	43.56	23	52.80%	2.5	58.5	28	23	82.14%	-15.56	1.34	37.6
SUBSYSTEM TOTAL		2273.6	1373.3	60.41%	44.1	384.8	1809.2	1316.9	72.79%	-464.4	29.34	333.6

TABLE 2-23. OR-89 A/AA

		400 Hz					270 Vdc					
	P/N	PWR_{IN}	PWR_{OUT}	EFF.	WEIGHT	VOLUME	PWR_{IN}	PWR_{OUT}	EFF.	Δ PWR	WEIGHT	VOLUME
Video Conv. PP-7197	708002-7											
A1	768689	87	51	58.62%	1.33							
A2	768689	87	51	58.62%	1.33							
A3	768689	87	51	58.62%	1.33							
A4	768689	87	51	58.62%	1.33							
A7	708896	440	310	70.46%	0.7							
A6	768682	87	51	58.62%	1.33							
A15	708742	1371	1316	95.99%	10.78							
A5	768681	119	80	67.23%	1.33							
TOTAL		2365	1961	82.92%	19.46	273.5	2155.2	1957	90.80%	-209.8	10.76	178.3
IR Viewer IP-1214	708001-7											
	744545	20	10.4	52.00%	1.32							
A5	788345	6	4.5	75.00%	1.32							
	SCR Bridge	1316	1290	98.02%	1.32							
PS1	715376	23	5	21.74%	1.32							
TOTAL		1365	1309.9	95.96%	5.28	73.4	1335.6	1309.9	98.08%	-29.4	2.99	119.4
IR Cont Conv. C-8759	708003-6											
	708279	6	5	83.33%	0.8							
	768682	87	51	58.62%	1.33							
	708277	105	48	45.71%	1.33							
	810262	56	45	80.36%	3.6							
TOTAL		254	149	58.66%	7.06	124.5	191.4	149	78.85%	-62.6	6.34	225.6
SUBSYSTEM TOTAL		2642	1793.9	67.90%	33.92	471.4	2340.2	1793.9	76.66%	-301.8	20.09	523.3

TABLE 2-24. AYK-10

		400 Hz					270 Vdc					
	P/N	PWR_{IN}	PWR_{OUT}	Eff.	Weight	Volume	PWR_{IN}	PWR_{OUT}	Eff.	ΔPWR	Weight	Volume
Pwr. Supply #1	713700-06	979	856	87.44%	31.7	1008	848.1	803.1	94.69%	-130.9	13.5	384
	713720-00	449.5	393	87.43%			406	384.3	94.69%			
	713720-00	282.5	247	87.44%			257.8	244.0	94.69%			
	713740-00	247	216	87.45%			223.1	211.2	94.69%			
Mem. dc/dc	7131775	216	158.8	73.52%	4.52	101	211.2	158.8	75.29%	-4.8	4.55	101
CPU dc/dc	7511300-00	247	175.0	70.85%	6.32	138	244.0	175.0	71.72%	-3.0	6.35	138
I/O dc/dc	7511200-00	393	285.2	72.57%	6.81	149	384.3	285.2	74.22%	-8.7	6.84	149
Totals		979	619	63.23%	49.35	1396	848.1	619	72.99%	-130.9	31.24	772
Pwr. Supply #2	7131700-07	893	777	87.01%	31.7	1008	800.1	754.4	94.29%	-92.9	13.5	384
	7131740-00	239	208	87.03%			210.3	198.1	94.29%			
	7131720-00	285	248	87.02%			257.4	242.5	94.29%			
	7131720-00	369	321	86.99%			333.1	313.8	94.29%			
Mem. dc/dc	7131775	208	155.1	74.57%	4.52	101	198.1	151.1	76.27%	-9.9	4.55	101
CPU dc/dc	7511300-00	248	177.1	71.41%	6.32	138	242.5	177.1	73.03%	-5.5	6.35	138
I/O dc/dc	7511200-00	321	229.7	71.56%	6.81	149	313.8	229.7	73.19%	-7.2	6.84	149
Totals		893	557.9	62.48%	49.35	1396	800.1	557.9	69.73%	-92.9	31.24	772
SUBSYSTEM TOTAL		1872	1176.9	62.87%	98.7	2792	1648.2	1176.9	71.41%	-223.8	62.48	1544

TABLE 2-25. AYN-5

		400 Hz					270 Vdc					
	P/N	PWR_{IN}	PWR_{OUT}	Eff.	Weight	Volume	PWR_{IN}	PWR_{OUT}	Eff.	ΔPWR	Weight	Volume
Pwr. Supply #1	2786869-1											
XFMR	1978869	91.98 17.82	87.95 17.04	95.62%								
A1	2435811-2	8.85	7.1	80.23%	4.56	112.8						
A2	2787117-2	21.9	17.3	79.00%								
A3	2786741-1	57.2	45.2	79.02%								
Totals		91.98	69.6	75.67%			90	69.6	77.33%	0.7	1.515	72
Pwr. Supply #2	2786869-1											
XFMR	1978869	91.98 17.82	87.95 17.04	95.62%								
A1	2435811-2	8.85	7.1	80.23%	4.56	112.8						
A2	2787117-2	21.9	17.3	79.00%								
A3	2786741-1	57.2	45.2	79.02%								
Totals		91.98	69.6	75.67%			90	69.6	77.33%	0.7	1.515	72
SUBSYSTEM TOTAL		183.96	139.2	75.67%	9.12	225.6	180	139.2	77.33%	1.4	3.03	144

TABLE 2-26.- SYSTEM WEIGHT ANALYSIS

SYS/WRA	W_{PS1}	W_C	W_{WRAI}	W_{SA}	$\frac{W_C}{W_{SA}}+1=K$	$W_{PS1}xK$	W_{PS2}	$W_{PS2}xK$	W_{WRA2}	W	W_{SYS1}	W_{SYS2}
OL-82												
PP-6671	36.5	12.2	48.7	36.5	1.3342	48.7	10.27	18.3	18.3	-30.4		
SG-962	9.44	20.04	46.14	26.10	1.7678	16.69	9.00	15.91	45.36	-0.78		
CV-2882	8.12	17.83	42.06	24.23	1.7198	13.97	7.67	13.19	41.28	-0.78		
CP-1140	8.22	19.47	45.77	26.30	1.7403	14.31	7.63	13.27	44.73	-1.04		
CV-2883	8.22	20.04	44.54	24.50	1.8180	14.93	7.84	14.25	43.86	-0.67		
CV-2882	8.12	17.83	42.06	24.23	1.7198	13.97	7.67	13.19	41.28	-0.78		
CP-1140	8.22	19.47	45.77	26.30	1.7403	14.31	7.63	13.27	44.73	-1.04		
TOTAL	86.84	126.88	315.04	188.16	1.6743	136.88	57.71	101.39	279.54	-35.49	417.0	381.51
ASA-82												
IP-1054	11.49	21.1	66.8	45.7	1.4617	16.79	7.49	10.95	60.96	-5.84		
IP-1054	11.49	21.1	66.8	45.7	1.4617	16.79	7.49	10.95	60.96	-5.84		
IP-1053	11.49	17.3	47.5	30.2	1.5728	18.07	7.16	11.25	40.68	-6.82		
IP-1051	10.63	12.0	34.0	22.00	1.5455	16.43	5.42	8.38	25.95	-8.05		
IP-1052	11.25	14.75	48.0	33.25	1.4436	16.24	3.33	4.18	35.94	-12.06		
CV-2806	11.27	45.4	80.0	34.6	2.3121	26.06	7.11	16.45	70.39	-9.61		
TOTAL	67.62	131.65	343.1	211.45	1.6226	110.38	38.00	61.66	294.38	-48.72	336.2	287.5
AYK-10												
PP-6678	16.3	15.4	31.7	16.3	1.9448	31.7	6.94	13.5	13.5	-18.2		
PP-6675	3.41	2.91	6.32	3.41	1.8534	6.32	3.43	6.35	6.35	+0.03		
PP-6676	2.91	1.61	4.52	2.91	1.5533	4.52	2.93	4.55	4.55	+0.03		
PP-6677	3.9	2.91	6.81	3.90	1.7462	6.81	3.90	6.84	6.84	+0.03		
PP-6679	16.3	16.3	32.6	16.3	2.000	32.6	6.75	13.5	13.5	-19.1		
PP-6675	3.41	2.91	6.32	3.41	1.8534	6.32	3.43	6.35	6.35	+0.03		
PP-6676	2.91	1.61	4.52	2.91	1.5533	4.52	2.93	4.55	4.55	+0.03		
PP-6677	3.90	2.91	6.81	3.90	1.7462	6.81	3.90	6.84	6.84	+0.03		
TOTAL	53.04	46.56	99.6	53.04	1.8778	99.6	34.21	62.48	62.48	-37.12	403.9	366.8

TABLE 2-26. SYSTEM WEIGHT ANALYSIS (Continued)

SYS/WRA	W_{PS1}	W_C	W_{WRAI}	W_{SA}	$\frac{W_C}{W_{SA}}+1=K$	$W_{PS1}xK$	W_{PS2}	$W_{PS2}xK$	W_{WRA2}	W	W_{SYS1}	W_{SYS2}
AYN-5												
PS1	4.56	10.56	30.4	19.84	1.5323	13.98	4.95	7.59	24.01	-6.39		
PS2	4.56											
TOTAL	9.13	10.56	30.4	19.84	1.5323	13.98	4.95	7.59	24.01	-6.39	30.6	24.21
ARC-153												
AM-6384	23.1	26.7	65.0	38.3	1.6971	39.3	16.5	28.0	53.7	-11.3		
RT-1016	2.38	12.89	27.99	15.1	1.8536	4.41	-	-	23.58	-4.41		
CU-1985	1.88	6.57	21.56	14.99	1.4383	2.7	1.01	1.45	20.31	-1.25		
TOTAL	27.36	46.16	114.55	68.39	1.6750	46.41	17.51	29.45	97.59	-16.96	109.7	92.74
OR-89												
PP-7179	19.46	6.62	34.7	28.08	1.2358	24.05	10.76	13.3	23.95	-10.75		
IP-1069	5.28	32.0	169.7	43.2	1.7407	9.19	2.99	5.2	165.71	-3.99		
C-8759	7.06	8.84	28.1	19.26	1.4590	10.3	4.85	7.08	24.88	-3.22		
TOTAL	31.8	47.46	232.5	90.54	1.5242	43.54	18.06	25.58	214.54	-17.96	232.5	215.54
6 SUBSYSTEM TOTAL	275.79	409.27	1135.27	631.42	1.6482	450.79	167.66	288.15	972.54	--162.64	1529.91	1367.3

established the total power supply weight component (W_T) was computed by $W_{PS} \times K = W_T$ where $K = W_c/W_{SA} + 1$. The K factor was then used to determine the total power supply weight for each new 270 Vdc design. This increased the weight savings from 108.13 pounds to 162.64 pounds. The average K factor (1.6482) was used in the remaining parametric evaluation.

2.1.5.8 Parametric Evaluation

The weight, efficiency, and power dissipation of the remaining 31 subsystem power supplies were estimated parametrically from the data compiled in paragraph 2.1.5.7.

2.1.5.8.1 Efficiency

Since all S-3A avionic subsystems were developed during the same time frame (when switched mode regulators were just coming into use and series pass regulators were the predominant method of satisfying secondary power requirements), it was assumed the same or similar circuit design technology was used in the development of all subsystem power supplies. Thus, the average efficiency of the six subsystems analyzed would be representative of the average power supply efficiency of the remaining subsystems and, thus, be a reasonably accurate value for parametric evaluation. The average efficiencies were 62.65 percent for the 400 Hz configuration, and 76.77 percent for the 270 Vdc configuration.

2.1.5.8.2 Power

The power dissipated by the remaining 31 subsystems for 115/200V, 400 Hz primary power source is:

$$P_T - P_o - P_{116} = P_R$$

where:

P_T = 25,651 watts (total avionic power dissipated)

P_O = 14,363 watts (total power dissipated by six subsystems evaluated)

P_{116} = 2,901 watts (power dissipated by APS-116)

$\therefore$ 25,651 - 14,363 - 2,901 = 8,387 watts (dissipated by the remaining 31 subsystems)

Of this value, 38.35 percent or 3216.4 watts are dissipated in the power supplies, leaving 62.65 percent or 5170.6 watts dissipated in signal processing circuitry.

The power dissipated by signal processing circuitry remains constant for both the 400 Hz and 270 Vdc primary power source, therefore

$$\frac{P_S}{\text{EFFICIENCY}} = P_N$$

where

P_N = new power dissipation of 31 subsystems

P_S = power dissipated by signal processing circuitry

$\frac{5170.6}{0.7677}$ = 6735.2 watts, total watts dissipated and

6735.2 x 0.2323 = 1565.6 watts are dissipated in the power supplies on the 270 Vdc system for a reduction of 1651.8 watts.

The total power reduction in all 38 subsystems was:

ΔP	6 subsystem evaluation groups	2386.4 watts
ΔP	APS-116	120.2 watts
ΔP	31 subsystems	1651.8 watts
	TOTAL ΔP	4158.4 watts

2.1.5.8.3 Weight

The new weight of the remaining 31 avionic subsystems and the resulting weight savings realized from the use of a 270 Vdc primary aircraft power

system and new advances in dc/dc converter technology was determined by the following methodology:

1. First, it was necessary to establish the ratio of weight savings to pound of weight in the six subsystems analyzed

$$\frac{W_O - W_N}{W_O} \tag{1}$$

where

W_O = original weight of the six subsystems analyzed

W_N = new weight of the six subsystems analyzed.

This ratio was then used to estimate the weight saving realizable in the remaining subsystems.

$$\frac{W_O - W_N}{W_O} = x\,W_R = W_R - W_F \tag{2}$$

where

W_R = original weight of the remaining subsystems

W_F = final weight of the remaining subsystems.

The total weight of the remaining subsystems could be calculated from the following equation if the power dissipation density of both groups of subsystems was the same

$$W_F = W_R - W_R \frac{W_O - W_N}{W_O} \tag{3}$$

2. The power density of the two groups of subsystems was not the same. Therefore, equations 2 and 3 had to be modified to compensate for this difference:

$$\frac{W_O - W_N}{W_O} \times W_R \times \frac{P_R}{P_O} = W_R \qquad (4)$$

$$W_F = W_R - \left(W_R \times \frac{W_O - W_N}{W_O} \times \frac{P_R}{P_O}\right) \qquad (5)$$

where

P_O = power dissipated in the six subsystems analyzed

P_R = power dissipated in the remaining subsystems

Equations 4 and 5 provide a relatively accurate method of para metrically estimating the new weight of the remaining subsystems as long as the same or similar circuit technology is used in all S-3A avionic power supplies.

3. Parametric evaluation was performed as follows:

$$\frac{W_O - W_N}{W_O} \times W_R \times \frac{P_R}{P_O} = \Delta W_R$$

W_O = 1529.4 lbs

W_N = 1366.76 lbs

W_R = 1576.8 lbs

P_R = 8387 W

P_O = 14,363 W

$$W_R = \frac{1529.4-1366.76}{1529.4} \times 1576.8 \times \frac{8387}{14,363}$$

W_R = 97.91 lbs (reduced power supply/system weight)

$$W_F = W_R - (W_R \times \frac{W_O - W_N}{W_O} \times \frac{P_R}{P_O}$$

$$W_F = 1576.8 - (1576.8 \times \frac{1528.4 - 1366.76}{1529.4} \times \frac{8387}{14,636}$$

W_F = 1478.89 lbs. (reduced power supply/ system weight for 31 subsystems)

4. The total S-3A system weight saved through the utilization of a 270 Vdc primary power system and advanced dc/dc converter technology would be:

ΔW of 6 subsystems		162.64 lbs
ΔW of remaining subsystems		97.91 lbs
ΔW of APS-116		7.55 lbs
	Δ W TOTAL	268.10 lbs

2.1.5.9 Power Supply Summary

Table 2-27 summarizes the total power supply evaluation effort on the 6 subsystems study group.

TABLE 2-27. 270 Vdc IMPACT SUMMARY

	Electrical									Mechanical													
	Input				Efficiency		P/S Dissipation			Weight (lb)				Volume (in.^{3})				Total S-3A			Total New		
SYS/WRA	S-3A	New	Δ	Output	S-3A	New	S-3A	New	Δ	S-3A	New	Δ	%	S-3A	New	Δ	%	S/S wt	P/S wt	% P/S wt	S/S wt	P/S wt	% P/S wt
EI 82																							
PP 6671	682	552	-130	409	59.97%	74.09%	273	143	-130	48.7	18.3	-30.4	-37.6%	1400	546	-854	-61%						
SG 962	733.5	656	-77.5	488.2	66.56%	74.42%	245.3	167.8	-77.5	9.44	9.0	-0.44	-4.7%	155	195.1	+40.1	+25.9%						
CV 2882	542.5	503.0	-39.5	406.5	74.93%	80.81%	136.0	96.5	-39.5	8.12	7.67	-0.45	-5.5%	141	160	+19	+13.5%						
CP 1140	582.0	552	-30.5	418.6	71.92%	75.83%	163.4	133.4	-30.5	8.22	6.4	-0.6	-8.6%	122	139.5	+17.5	+14.3%						
CV-2883	727.5	657.8	-69.7	496.2	68.21%	75.43%	231.3	161.6	-69.7	8.22	7.84	-0.38	-4.6%	135	169.6	+34.6	+25.6%						
CV 2882	542.5	503.0	-39.5	406.5	74.93%	80.81%	136.0	96.5	-39.5	8.12	7.67	-0.45	-5.5%	141	160	+19	+13.5%						
CP 1140	582.0	552	-30.5	418.6	71.86%	75.83%	163.4	133.4	-30.5	8.22	6.4	-0.6	-8.6%	122	139.5	+17.5	+14.3%						
TOTAL (S/S)	4209	3791.8	-417.2	2860.5	67.96%	75.44%	1348.4	931.2	-417.2	99.04	63.28	-35.49	-33.54%	2216	1509.7	-706.3	-31.87%	417.0	86.84	20.8%	381.5	57.71	15.1%
ASA 82																							
IP-1054	577	395	-182	350.5	60.75%	88.71%	226.5	44.5	-182.0	11.49	7.49	-4.00	-34.81%	116.1	146.8	+30.7	+26.44%						
IP-1054	577	395	-182	350.5	60.75%	88.73%	226.5	44.5	-182	11.49	7.49	-4.00	-34.81%	116.1	146.8	+30.7	+26.4%						
IP-1053	552	377	-175	334.9	60.67%	88.83%	217.1	42.1	-175	11.49	7.15	-4.34	-37.8 %	116.1	146.8	+30.7	+26.4%						
IP-1051	437	285.8	-151.2	241.6	55.29%	84.54%	195.4	44.2	-151.2	10.63	5.41	-5.22	-49.10%	130.8	165.4	+34.6	+26.5%						
IP-1052	263	168.0	-87	144	54.75%	85.71%	119.0	24	-95	11.25	3.34	-7.91	-61.42%	130.8	165.4	+34.6	+26.5%						
CV-2806	672	375.0	297	300	44.64%	80.0%	372	75	-297.0	11.27	7.12	-4.15	-36.82%	174.3	178.3	+4.0	+2.3%						
	3078	1995.8	-1074.2	1721.5	55.93%	82.26%	1356.5	274.3	-1074.2	67.62	38.0	-29.62	-42.32%	784.2	949.5	+161.3	+20.6%	336.2	67.62	20.11%	307.6	38.0	12.4%
AYK 10																							
PP-6679	979	848.1	-130.9	(856)803.1	87.44%	94.69%	123	45	-78	31.7	13.[illegible]	-18.2	-57.6%	1008	384	-624	-61.9%						
PP 6675	247	244	-3	175	70.85%	71.72%	72	69	-3	6.32	6.35	+0.03	+0.5%	138	138	-0-	-0-						
PP-6676	216	211.2	-4.8	159	73.51%	75.28%	57	52.2	-4.8	4.52	4.55	+0.03	+0.7%	101	101	-0-	-0-						
PP 6677	393	384.1	-8.7	285.2	72.51%	74.21%	107.8	99.1	-8.7	6.81	6.84	+0.03	+0.4%	149	149	-0-	-0-						
PP 6678	893	800.1	-92.9	(777)754.4	87.01%	94.29%	116	45.7	-70.3	32.6	13.[illegible]	-19.1	-58.6%	1008	384	-624	61.9%						
PP 6675	248	242.5	-5.5	177.1	71.41%	73.03%	70.9	65.4	-5.5	6.32	6.35	+0.03	+0.5%	138	138	-0-	-0-						
PP 6676	208	198.1	-9.9	151.1	74.57%	76.28%	56.9	47	-9.9	4.53	4.55	+0.02	+0.4%	101	101	-0-	-0-						
PP-6677	321	313.8	-7.2	229.3	71.24%	73.20%	91.3	84.1	-7.2	6.81	6.84	+0.03	+0.4%	149	149	-0-	-0-						
	1872	1648.2	-223.8	1176.9	62.88%	71.42%	694.9	507.5	-187.4	98.72	62.[illegible]	-36.23	-36.71%	2792	1544	-1248	-44.7%	403.9	98.72	24.4%	367.67	62.48	17.0%
AYN 5																							
P.S. #1	91.98	90.0	0.69	69.6	75.66%	77.33%	21.1	20.4	-0.7	4.56	3.17	-1.39	30.5%	112.8	72	-40.8	-36.2%						
P.S. #2	91.98	90.0	-0.69	69.6	75.66%	77.33%	21.1	20.4	-0.7	4.56	3.17	-1.39	30.5%	112.8	72	-40.8	-36.2%						
	183.96	180.0	-1.38	139.2	75.66%	77.33%	42.2	40.8	-1.4	9.12	6.34	-2.78	30.5%	225.6	144	-81.6	-36.2%	30.6	9.12	[illegible]	25.08	6.34	25.3%
ARC 153																							
AM 6384	2173.6	1843.5	-330.1	1344.1	61.84%	72.91%	829.5	499.4	-330.1	39.3	28	-11.3	-28.8%	282	496	+214	+75.9%						
RT 1016	87	45	-42	36.8	42.3%	81.78%	50.2	8.2	-42.0	2.3	-0-	-2.3	-100%	44.3	-0-	-44.3	-100%						
CU-1985	43.56	28	15.56	23	52.8%	82.14%	20.56	5.0	-15.56	2.5	1.34	-1.16	-46.4%	58.5	37.6	-20.9	-35.7%						
	2273.6	1871.5	-345.66	1373.3	60.40%	73.38%	900.3	512.6	-464.4	44.1	29.34	-14.76	-33.5%	384.8	533.6	+148.8	+38.7%	109.7	44.3	40.2%	94.94	29.34	30.9%
OR-89																							
PP-7197	994	822.2	171.8	645	64.89%	78.45%	349	173.2	-175.8	19.68	10.76	-8.92	-45.3%	273.5	178.3	-95.2	-30.8%						
	(1371)	(1333)	38	(1316)1312	95.99%	98.42%	55	21	-18														
IP 1069	49	23.6	-19.4	19.9	40.61%	84.32%	29.1	3.7	-25.4	5.28	2.99	-2.29	-43.3%	73.4	119.4	+46	+62.7%						
	(1316)	(1312)	4	1290	98.04%	98.32%	26	22	-4														
C 8759	254	191.4	62.6	149	58.66%	78.85%	105	42.4	-62.6	8.96	6.34	-2.62	-29.2%	124.5	225.6	+101.1	+81.2%						
	1291	1037.2	-253.8	813.9	63.04%	78.47%	438.1	136.3	-301.8	33.92	20.09	-13.83	-31.97	471.4	523.3	+51.9	+11.0%	252	33.92	[illegible]	238.2	20.09	8.4%
	(1371)	(1333)	(42)	(1290)	95.09%	96.86%																	

2.2 RELIABILITY ANALYSIS

Failure histories on existing S-3A power supplies were utilized to provide a basis for analyzing the impact of the new 270 Vdc designs on reliability. Results of this analysis, as presented in this section of the report, reveal 270 Vdc power supply reliability would normally be inhibited by two factors: (1) the requirement for components, particularly semiconductors, to operate at relatively high voltages and (2) the added complexity of switching regulators as opposed to transformer-rectifier power supplies. These factors are offset by the tighter reliability controls placed on piece parts, state-of-the-art improvement, and lower operating temperatures which will be experienced due to higher power supply efficiencies.

A consultant power supply manufacturer (Reference 1) prepared reliability predictions for a representative group of S-3A power supplies using 270V dc/dc converter techniques. These predictions were based upon MIL-HDBK-217B generic failure rates and derating criteria and were calculated using two environmental conditions:

- Forced air cooled, 60°C component mounting surface temperature. (existing S-3A ECS)
- Cooled by 5°C cold plate, 10°C component mounting surface temperature (Freon/vapor cycle S-3A ECS)

A predicted MTBF of 1022 hours was obtained for the surveyed group with air cooling and 2501 hours with Freon cooling. Detailed analysis work sheets for these power supplies are shown in Tables 2-28 through 2-40.

A detailed analysis of 3M maintenance data was then conducted to determine the equivalent reliability of the existing S-3A power supplies using the same failure criteria ground rules, i.e.:

- Only maintenance actions resulting in I-Level repair were included
- Failure modes observed in the 3M data but not included in the prediction were not considered, i.e., mounting hardware connectors, wiring, etc.

TABLE 2-28. APS-116 HIGH VOLTAGE POWER SUPPLY FAILURE RATE WORKSHEET

Qty	Type	Cooled by forced air, 14 lb/kW Pd, 103°F Tmax air in, +17°F rise in air temp, +20°F rise from air to mounting. Mounting surface = 140°F = 60°C					Cooled by 5°C cold plate				
		V Stress	P Stress	Temp °C	λ/Unit	λ Total	V Stress	P Stress	Temp °C	λ/Unit	λ Total
7	Pwr NPN (JAN)	0.6	0.1	90	1.5675	10.973	0.6	0.1	40	0.8910	6.237
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
11	Sig NPN (JAN)	0.4	>0.1	70	0.2700	2.970	0.4	>0.1	20	0.1548	1.703
12	Hi V. Rectifier	0.4	0.2	110	3.3600	40.320	0.4	0.2	60	0.9975	11.970
7	Hi speed Pwr Diode (JAN)	0.6	0.2	110	0.5600	3.920	0.6	0.2	60	0.2188	1.531
14	Sig Diode (JAN)	0.3	>0.1	70	0.2013	2.818	0.3	>0.1	20	0.1050	1.470
2	I.C. Lin (JAN	-	-	95	2.900	5,800	-	-	45	0.9816	1.963
38	RCR's	-	0.1	70	0.0036	0.137	-	0.1	20	0.0004	0.015
8	RNR's	-	0.1	70	0.0013	0.010	-	0.1	20	0.0008	0.007
7	RWR's	-	0.2	90	0.0426	0.298	-	0.2	40	0.0270	0.189
1	RTR	-	0.1	70	0.1260	0.126	-	0.1	20	0.0832	0.083
16	Caps - Tant.	0.6	-	70	0.1000	1.600	0.6	-	20	0.0600	0.960
6	Caps - Ceramic	0.4	-	70	0.0312	0.187	0.4	-	20	0.0272	0.163
13	Caps - Hi V. Film	0.4	-	70	0.0312	0.406	0.4	-	60	0.0272	0.354
5	Chokes	-	-	110	0.3200	1.600	-	-	60	0.2170	1.085
3	Low Power Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
2	Output Xform.	-	-	110	0.6800	1.360	-	-	60	0.4610	0.922
1	Zener reg.	-	-.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
						Σλ = 74.947					Σλ = 30.085

TABLE 2-29. APS-116 LOW VOLTAGE POWER SUPPLY FAILURE RATE WORKSHEET

		Cooled by forced air, 14 lb/kW Pd, $103^{o}F$ Tmax air in, $+17^{o}F$ rise in air temp, $+20^{o}F$ rise from air to mounting. Mounting Surface = $140^{o}F$ = $60^{o}C$.					Cooled by $5^{o}C$ Cold Plate				
Qty	Type	V Stress	P Stress	Temp °C	λ/Unit	λ Total	V Stress	P Stress	Temp °C	λ/Unit	λ Total
6	Pwr NPN (JAN)	0.6	0.1	90	1.5675	9.405	0.6	0.1	40	0.8910	5.346
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
12	Sig NPN (JAN)	0.4	>0.1	70	0.2700	3.240	0.4	>0.1	20	0.1458	1.858
14	Rectifiers (JTX)	0.4	0.2	110	0.6720	9.408	0.4	0.2	60	0.1344	1.882
6	Fast Pwr Diodes (JAN)	0.6	0.2	110	0.5600	3.360	0.6	0.2	60	0.2188	1.313
7	Sig Diodes (JAN)	0.3	>0.1	70	0.2013	1.409	0.3	>0.1	20	0.1050	0.735
3	I.C. Lin (JAN)	-	-	95	2.900	8.700	-	-	45	0.9816	2.945
27	RCR's	-	0.1	70	0.0036	0.097	-	0.1	20	0.0004	0.011
5	RNR's	-	0.1	70	0.0013	0.007	-	0.1	20	0.0008	0.004
11	RWR's	-	0.2	90	0.0426	0.469	-	0.2	40	0.0270	0.297
1	RTR	-	0.1	70	0.1260	0.126	-	0.1	20	0.0832	0.083
6	Caps - Tant.	0.6	-	70	0.1000	0.600	0.6	-	20	0.0600	0.360
6	Caps - Ceramic	0.4	-	70	0.0312	0.187	0.4	-	20	0.0272	0.163
6	Led's (JAN)	-	0.1	70	0.1360	0.816	-	> 0.1	20	0.0200	0.120
2	Chokes	-	-	110	0.3200	0.640	-	-	60	0.2170	0.434
2	Lo Pwr Xform.	-	-	110	0.1240	0.248	-	-	60	0.0840	0.168
1	Output Xform.	-	-	110	0.6800	0.680	-	-	60	0.4610	0.461
						$\Sigma\lambda = 40.679$					$\Sigma\lambda = 16.873$

TABLE 2-30. ARC 153A MULTIPLE POWER SUPPLY FAILURE RATE WORKSHEET

Qty	Type	V Stress	Cooled by moving air, 6 lb/kW Pd, 80^oF Tmax for air, $+40^oF$ rise in air, $+20^oF$ rise from air to heatsink. Mounting surface = 140^oF = 60^oC.				V Stress	Cooled by 5^oC Cold Plate			
			P Stress	Temp ^oC	λ/Unit	λ Total		P Stress	Temp ^oC	λ/Unit	λ Total
15	Pwr NPN (JAN)	0.6	0.1	90	1.5675	23.513	0.6	0.1	40	0.8910	13.365
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
28	Sig NPN (JAN)	0.4	>0.2	70	0.2700	7.560	0.4	>0.2	20	0.1548	4.334
2	Hi Volt Rectifier	0.4	0.2	100	3.3600	6.720	0.4	0.2	50	0.9975	1.995
40	Rectifiers (JANTX)	0.4	0.2	110	0.6720	26.880	0.4	0.2	60	0.1344	5.376
15	Hi speed Pwr Diode	0.6	0.2	110	0.5600	8.400	0.6	0.2	60	0.2188	3.282
21	I.C. (LIN) (JAN)	-	-	95	2.9000	60.900	-	-	45	0.9816	20.614
1	Zener reg. (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
31	Caps Ceramic	0.4	-	70	0.0312	0.967	0.4	-	20	0.0272	0.843
82	Caps Tant.	0.6	-	70	0.1000	8.200	0.6	-	20	0.0600	4.920
49	RCR's	-	0.1	70	0.0036	0.176	0.1	0.1	20	0.0004	0.020
30	RNR's	-	0.1	70	0.0013	0.039	0.1	0.1	20	0.0008	0.024
27	RWR's	-	0.2	90	0.0426	1.150	0.2	0.2	40	0.0270	0.729
15	RTR's	-	0.1	70	0.1260	1.890	0.1	0.1	20	0.0832	1.248
13	Chokes	-	-	110	0.1360	1.768	-	-	60	0.0840	1.092
7	Lo Pwr Xform.	-	-	110	0.1360	0.952	-	-	60	0.0840	0.588
4	Output Xform.	-	-	110	0.1360	0.544	-	-	60	0.0840	0.336
						$\Sigma\lambda$ = 151.709					$\Sigma\lambda$ = 59.947

TABLE 2-31. AYN/5A FAILURE RATE WORKSHEET

			Cooled by moving air, 6 lb/kW Pd, 80°F Tmax air in, +40°F rise in air, +20°F rise from air to mounting. Mounting surface = 140°F = 60°C.					Cooled by 5°C Cold Plate			
Qty	Type	V Stress	P Stress	Temp °C	λ/Unit	λ Total	V Stress	P Stress	Temp °C	λ/Unit	λ Total
4	Pwr NPN (JAN)	0.6	0.1	90	1.5675	6.270	0.6	0.1	40	0.8910	3.564
1	Pwr PNP (JAN)	0.6	0.1	80	1.2870	1.287	0.6	0.1	30	0.6930	0.693
5	Sig PNP (JAN)	0.4	0.1	70	0.2700	1.350	0.4	0.1	20	0.1548	0.774
20	Rectifiers (JTX)	0.4	0.2	110	0.6720	13.440	0.4	0.2	60	0.1344	2.688
4	Fast Pwr Diodes (JAN)	0.6	0.2	110	0.5600	2.240	0.6	0.2	60	0.2188	0.875
1	Zener reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
9	I.C. Lin (JAN)	-	-	95	2.9000	26.100	-	-	45	0.9816	8.834
30	RNR's	-	0.1	70	0.0013	0.039	-	0.1	20	0.0008	0.024
24	RCR's	-	0.1	70	0.0036	0.086	-	0.1	20	0.0004	0.010
8	RWR's	-	0.2	90	0.0426	0.341	-	0.2	40	0.0270	0.216
31	Cap Tant	0.6	-	70	0.1000	3.100	0.6	-	20	0.0600	1.860
10	Cap Ceramic	0.4	-	70	0.0312	0.312	0.4	-	20	0.0272	0.272
6	Chokes	-	-	110	0.1240	0.744	-	-	60	0.0840	0.504
2	Lo Pwr Xform.	-	-	110	0.1240	0.248	-	-	60	0.0840	0.168
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
						Σλ = 56.444					Σλ = 21.054
						X2 = 112.888					X2 = 42.108

TABLE 2-32. DGU FAILURE RATE WORKSHEET

Qty	Type	V Stress	Cooled by moving air, 6 lb/kW Pd, $80^{o}F$ Tmax air in, $+40^{o}F$ rise in air, $+20^{o}F$ rise from air to mounting. Mounting surface = $140^{o}F$ = $60^{o}C$.				V Stress	Cooled by $5^{o}C$ cold plate			
			P Stress	Temp ^{o}C	λ/Unit	λ Total		P Stress	Temp ^{o}C	λ/Unit	λ Total
6	Pwr NPN (JAN)	0.6	0.1	90	1.5675	9.405	0.6	0.1	40	0.8910	5.346
1	Pwr PNP (JAN)	0.6	0.1	80	1.2870	1.287	0.6	0.1	30	0.6930	0.693
21	Sig NPN (JAN)	0.4	0.1	70	0.2700	5.670	0.4	0.1	20	0.1548	3.251
24	Rectifiers (JTX)	0.4	0.2	110	0.6720	16.128	0.4	0.2	60	0.1344	3.226
6	Hi Speed Pwr Diodes (JAN)	0.6	0.2	110	0.5600	3.360	0.6	0.2	60	0.2188	1.313
14	Sig Diodes (JAN)	0.3	0.1	70	0.2013	2.818	0.3	0.1	20	0.1050	1.470
12	Led's (JAN)	-	>0.1	70	0.1360	1.632	-	>0.1	20	0.0200	0.240
3	I.C. LIN (JAN)	-	-	95	2.9000	8.700	-	-	45	0.9816	2.945
1	Caps Tant.	0.6	-	70	0.1000	3.100	0.6	-	20	0.0600	1.860
10	Caps Ceramic	0.4	-	70	0.0312	0.312	0.4	-	20	0.0272	0.272
1	Zener reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
58	RCR's	-	0.1	70	0.0036	0.209	-	0.1	20	0.004	0.023
6	RNR's	-	0.1	70	0.0036	0.008	-	0.1	20	0.0008	0.005
16	RWR's	-	0.2	90	0.0426	0.682	-	0.2	40	0.0270	0.432
1	RTR	-	0.1	70	0.1260	0.126	-	0.1	20	0.0832	0.083
14	Chokes	-	-	110	0.1240	1.736	-	-	60	0.0840	1.176
3	Lo Power Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
3	Hi Power Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
						$\Sigma\lambda$ = 56.679					$\Sigma\lambda$ = 23.321
						2 units = 113.358					2 units = 46.642

TABLE 2-33. TACCO DISPLAY 29 VDC POWER SUPPLY FAILURE RATE WORKSHEET

			Cooled by moving air, 6 lb/kW Pd. $80^{o}F$ Tmax air $+40^{o}F$ rise in air, $+20^{o}F$ rise from air to heatsink. Mounting surface = $140^{o}F$ = $60^{o}C$.					Cooled by 5^{o} cold plate			
Qty	Type	V Stress	P Stress	Temp °C	λ/Unit	λ/Total	V Stress	P Stress	Temp °C	λ/Unit	λ/Total
5	Pwr NPN (JAN)	0.6	0.1	90	1.5675	7.838	0.6	0.1	40	0.8910	4.455
1	Pwr PNP (JAN)	0.6	0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
8	Sig NPN (JAN)	0.4	0.1	70	0.2700	2.160	0.4	>0.1	20	0.1548	1.238
4	Hi Current Rect. (JAN)	0.6	0.2	110	3.3600	13.440	0.6	0.2	60	0.9975	3.990
6	Low Current Rect.	0.1	0.1	90	0.2890	1.734	0.1	0.1	40	0.1140	0.684
5	Hi Speed Diodes (JAN)	0.6	0.2	110	0.5600	2.800	0.6	0.2	60	0.2188	1.094
1	I.C. (Lin) (JAN)	-	-	95	2.9000	2.900	-	-	45	0.9816	0.982
1	Zener Reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	488
6	Caps, Ceramic.	0.4	-	70	0.0312	0.187	0.4	-	20	0.0272	0.163
13	Caps, Tant.	0.6	-	70	0.1000	1.300	0.6	-	20	0.0600	0.780
17	RCR's	-	0.1	70	0.0036	0.061	-	0.1	20	0.0004	0.007
4	RNR's	-	0.1	70	0.0013	0.005	-	0.1	20	0.0008	0.003
5	RWR's	-	0.2	90	0.0426	0.213	-	0.2	40	0.2700	0.135
1	RTR	-	0.1	70	0.1260	0.126	-	0.1	20	0.0832	0.083
4	Chokes	-	-	110	0.1240	0.496	-	-	60	0.0840	0.336
3	Lo Pwr Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
						Σλ = 35.806					Σλ = 15.467

TABLE 2-34. TACCO DISPLAY POWER SUPPLY, MULTIPLE OUTPUT, FAILURE RATE WORKSHEET

Qty	Type	V Stress	Cooled by moving air, 6 lb/kW Pd, 80°F Tmax air in, +40°F rise in air temp, +20°F rise from air to mounting. Mounting surface = 140°F = 60°C.				V Stress	Cooled by 5°C cold plate			
			P Stress	Temp °C	λ/Unit	λ/Total		P Stress	Temp °C	λ/Unit	λ/Total
4	Pwr NPN (JAN)	0.6	0.1	90	1.5675	6.270	0.6	0.1	40	0.8910	3.564
1	Pwr PNP (JAN)	0.6	0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
7	Sig NPN (JAN)	0.4	0.1	70	0.2700	1.890	0.4	>0.1	20	0.1548	1.084
6	Rectifiers (JAN)	0.4	0.2	110	3.3600	20.160	0.4	0.2	60	0.9975	5.985
4	Hi speed pwr diodes (JAN)	0.6	0.2	110	0.5600	2.240	0.6	0.2	60	0.2188	0.875
6	Low Current Rect. (JAN)	0.1	0.1	90	0.2890	1.734	0.1	0.1	40	0.1140	0.684
3	I.C. (LIN)	-	-	95	2.9000	8.700	-	-	45	0.9816	2.945
1	Zener reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
7	Caps ceramic	0.4	-	70	0.3120	2.184	0.4	-	20	0.0272	0.190
22	Caps Tant.	0.6	-	70	0.1000	2.200	0.6	-	20	0.0600	1.320
20	RCR's	-	0.1	70	0.0036	0.072	-	>0.1	20	0.0004	0.008
4	RNR's	-	0.1	70	0.0013	0.005	-	>0.1	20	0.0008	0.003
6	RWR's	-	0.2	90	0.0426	0.256	-	0.2	40	0.0270	0.162
1	RTR's	-	0.1	70	0.1260	0.126	-	>0.1	20	0.0832	0.083
6	Chokes	-	-	110	0.1240	0.744	-	-	60	0.0840	0.504
3	Low Pwr Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
1	Output Xform	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
3	Led's.	-	-	70	0.1360	0.408	-	>0.1	20	0.0200	0.060
						Σλ = 49.534					Σλ = 18.984
						2 Units = 99.069					2 Units = 37.968

TABLE 2-35. TACCO DISPLAY H.V. POWER SUPPLY FAILURE RATE WORKSHEET

			Cooled by moving air, 6 lb/kW Pd, $80^{o}F$ Tmax air, $+40^{o}F$ rise in air $+20^{o}F$ rise from air to heat sink. Mounting surface = $140^{o}F$ = $60^{o}C$.					Cooled by $5^{o}C$ cold plate.			
Qty	Type	V Stress	P Stress	Temp ^{o}C	λ/Unit	λ/Total	V Stress	P Stress	Temp ^{o}C	λ/Unit	λ/Total
3	Pwr NPN (JAN)	0.6	0.1	90	1.5675	4.703	0.6	0.1	40	0.8910	2.673
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
4	Sig NPN (JAN)	0.4	>0.1	70	0.2700	1.080	0.4	>0.1	20	0.1548	0.619
12	H.V. Rectifiers	0.4	0.2	100	3.3600	40.320	0.4	0.2	50	0.9975	11.970
3	Hi speed pwr Diodes (JAN)	0.6	0.2	110	0.5600	1.680	0.6	0.2	60	0.2188	0.656
1	I.C. Lin (JAN)	-	-	95	2.9000	2.900	-	-	45	0.9816	0.982
2	Sig Diodes (JAN)	0.3	0.1	70	0.2013	0.403	0.3	>0.1	20	0.1050	0.210
16	Caps ceramic	0.4	-	70	0.0312	0.499	0.4	-	20	0.0272	0.163
12	Caps - Tant.	0.6	-	70	0.1000	1.200	0.5	-	20	0.0600	0.720
1	Zener Reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
15	RCR's	-	0.1	70	0.0036	0.054	-	>0.1	20	0.0004	0.006
6	RNR's	-	0.1	70	0.0013	0.008	-	>0.1	20	0.0008	0.005
1	RTR	-	0.1	70	0.1260	0.126	-	>0.1	20	0.0832	0.083
3	Choke	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
1	Lo Power Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
						$\Sigma\lambda = 55.642$					$\Sigma\lambda = 19.688$

TABLE 2-36. PP-5671A - POWER SUPPLY, MULTIPLE OUTPUT (OL-82A SYSTEM) FAILURE RATE WORKSHEET

			Cooled by moving air, 6 lb/kW Pd, 80°F Tmax air in, +40°F rise in air temp, +20°F rise from air to mounting. Mounting Surface = 140°F = 60°C.					Cooled by 5°C cold plate.			
Qty	Type	V Stress	P Stress	Temp °C	λ/Unit	λ Total	V Stress	P Stress	Temp °C	λ/Unit	λ Total
8	Pwr NPN (JAN)	0.6	0.1	90	1.5675	12.540	0.6	0.1	40	0.8910	7.128
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
25	Sig NPN (JAN)	0.4	>0.1	70	0.2700	6.750	0.4	>0.1	20	0.1548	3.870
18	Rectifiers (JTX)	0.4	0.2	110	0.6720	12.096	0.4	0.2	60	0.1344	2.419
4	Fast Pwr Diodes (JAN)	0.6	0. 2	110	0.5600	2.240	0.6	0.2	60	0.2188	0.875
12	Sig Diodes (JAN)	0.3	>0.1	70	0.2013	2.416	0.3	>0.1	20	0.1050	1.260
4	I.C. Lin (JAN)	-	-	95	2.9000	11.600	-	-	45	0.9816	3.926
3	I.C. Digital (JAN)	-	-	70	0.3984	1.195	-	-	20	0.3295	0.989
65	RCR's	-	0.1	70	0.0036	0.234	-	0.1	20	0.0004	0.026
12	RNR's	-	0.1	70	0.0036	0.016	-	0.1	20	0.0008	0.010
11	RWR's	-	0.2	90	0.0426	0.469	-	0.2	40	0.0270	0.297
1	RTR	-	0.1	70	0.1260	0.126	-	0.1	20	0.0832	0.083
36	Caps - Tant.	0.6	-	70	0.1000	3.600	0.6	-	20	0.0600	2.160
10	Caps - Ceramic	0.4	-	70	0.0312	0.312	0.4	-	20	0.0272	0.272
12	Chokes	-	-	110	0.1240	1.488	-	-	60	0.0840	1.008
6	Lo Pwr Xform.	-	-	110	0.1240	0.744	-	-	60	0.0840	0.504
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
4	Led's (JAN)	-	>0.1	70	0.1360	0.544	-	>0.1	20	0.0200	0.080
1	Zener reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
						Σλ = 58.543					Σλ = 26.172
						X2 = 117.086					X2 = 52.344

TABLE 2-37. OL82A POWER INVERTER, REF 1023771 FAILURE RATE WORKSHEET

			Cooled by moving air, 6 lb/kW Pd, $80^{o}F$ Tmax Air in, $+40^{o}F$ rise in air temp, $+20^{o}F$ rise from air to mounting, Mounting surface = $140^{o}F$ = $60^{o}C$.					Cooled by $5^{o}C$ cold plate			
Qty	Type	V Stress	P Stress	Temp ^{o}C	λ/Unit	λTotal	V Stress	P Stress	Temp ^{o}C	λ/Unit	λTotal
5	Pwr NPN (JAN)	0.6	0.1	90	1.5675	7.838	0.6	0.1	40	0.8910	4.455
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
8	Sig NPN (JAN)	0.4	>0.1	70	0.2700	2.160	0.4	>0.1	20	0.1548	1.238
8	Rectifier (JAN)	0.4	0.2	110	3.3600	26.880	0.4	0.2	60	0.9975	7.980
5	Fast Pwr Diode (JAN)	0.6	0.2	110	0.5600	2.800	0.6	0.2	60	0.2188	1.094
12	Sig Diode (JAN)	0.3	>0.1	70	0.2013	2.416	0.3	>0.1	20	0.1050	1.260
1	I.C. Lin (JAN)	-	-	95	2.9000	2.900	-	-	45	0.9816	0.982
16	RCR's	-	0.1	70	0.0036	0.058	-	0.1	20	0.0040	0.006
8	RNR's	-	0.1	70	0.0013	0.010	-	0.1	20	0.0080	0.006
4	RWR's	-	0.2	90	0.0426	0.170	-	0.2	40	0.0270	0.108
1	RTR	-	0.1	70	0.1260	0.126	-	0.1	20	0.0832	0.083
18	CAPS - Tant.	0.6	-	70	0.1000	1.800	0.6	-	20	0.0600	1.080
6	CAPS - Ceramic	0.4	-	70	0.0312	0.600	0.4	-	20	0.0272	0.163
6	Chokes	-	-	110	0.1240	0.744	-	-	60	0.0840	0.504
3	Lo Pwr Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
1	Zener	-	0.2	40	0.7625	0.763	-	0.2	40	0.4875	0.488
						$\Sigma\lambda$ = 51.047					$\Sigma\lambda$ = 20.477

TABLE 2-38. AYK-10A INPUT REGULATOR, REF P/N 7131700-06, FAILURE RATE WORKSHEET

Qty	Type	V Stress	Cooled by moving air, 6 lb/kW Pd, 80°F Tmax air in, +40°F rise in air temp, +20°F rise from air to mounting, Mounting surface = 140°F = 60°C				V Stress	Cooled by 5°C cold plate			
			P Stress	Temp °C	λ/Unit	λ Total		P Stress	Temp °C	λ/Unit	λ Total
7	Pwr NPN (JAN)	0.6	0.1	90	1.5675	10.973	0.6	0.1	40	0.8910	6.237
1	Pwr PNP (JAN)	0.6	>0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
14	Sig NPN (JAN)	0.4	>0.1	70	0.2700	3.780	0.4	>0.1	20	0.1548	2.167
6	Rectifiers (JTX)	0.4	0.2	110	0.6720	4.032	0.4	0.2	60	0.1344	0.806
6	Fast Pwr Diodes (JAN)	0.6	0.2	110	0.5600	3.360	0.6	0.2	60	0.2188	1.313
1	Zener Reg (JAN)	-	0.2	90	0.7625	0.763	-	0.2	40	0.4875	0.488
1	Zener Ref (JAN)	-	0.2	90	1.1438	1.144	-	0.2	40	0.7313	0.731
13	Sig Diodes (JAN)	0.3	>0.1	70	0.2013	2.617	0.3	> 0.1	20	0.1050	1.365
3	I.C. Lin (JAN)	-	-	95	2.9000	8.700	-	-	45	0.9816	2.945
33	RCR's	-	0.1	70	0.0036	0.119	-	0.1	20	0.0004	0.013
25	RNR's	-	0.1	70	0.0013	0.033	-	0.1	20	0.0008	0.020
6	RWR's	-	0.2	90	0.0426	0.256	-	0.2	40	0.0270	0.162
3	RTR's	-	0.1	70	0.1260	0.378	-	0.1	20	0.0832	0.250
36	Caps - Tant.	0.6	-	70	0.1000	3.600	0.6	-	20	0.0600	2.160
13	Caps - Ceramic	0.4	-	70	0.0312	0.406	0.4	-	20	0.0272	0.354
11	Chokes	-	-	110	0.1240	1.364	-	-	60	0.0840	0.924
6	Low Pwr Xform.	-	-	110	0.1240	0.744	-	-	60	0.0840	0.504
3	Output Xform.	-	-	110	0.1240	0.372	-	-	60	0.0840	0.252
						Σ λ = 43.925					Σ λ = 21.383

TABLE 2-39. AYK-10A CONVERTER, REF P/N 7511300-00 (PP-6675), FAILURE RATE WORKSHEET

Qty	Type	V Stress	Cooled by moving air, 6 lb/kW Pd, $80^{o}F$ Tmax air in, $+40^{o}F$ rise in air temp, $+20^{o}F$ rise from air to mounting, Mounting surface = $140^{o}F$ = $60^{o}C$.				V Stress	Cooled by $5^{o}C$ cold plate			
			P Stress	Temp ^{o}C	λ/Unit	λ Total		P Stress	Temp ^{o}C	λ/Unit	λ Total
2	Pwr NPN (JAN)	0.6	0.1	90	1.5675	3.135	0.6	0.1	40	0.8910	1.782
4	Sig NPN (JAN)	0.6	>0.1	70	0.2700	1.080	0.6	>0.1	20	0.1548	0.619
10	Rectifiers (JTX)	0.4	0.2	110	0.6720	6.720	0.4	0.2	60	0.1344	1.344
12	Sig Diodes (JAN)	0.3	>0.1	70	0.2013	2.416	0.3	>0.1	20	0.1050	1.260
2	I.C. Lin (JAN)	-	-	95	2.9000	5.800	-	-	45	0.9816	1.963
13	RCR's	-	0.1	70	0.0036	0.049	-	0.1	20	0.0004	0.005
6	RWR's	-	0.2	90	0.0426	0.256	-	0.2	40	0.0270	0.162
19	Caps - Tant.	0.6	-	70	0.1000	1.900	0.6	-	20	0.0600	1.140
5	Caps - Ceramic	0.4	-	70	0.0312	0.156	0.4	-	20	0.0272	0.136
6	Chokes	-	-	110	0.1240	0.744	-	-	60	0.0840	0.504
5	Lo Pwr Xform.	-	-	110	0.1240	0.620	-	-	60	0.0840	0.420
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
					$\Sigma\lambda$ = 22.997					$\Sigma\lambda$ = 9.420	

TABLE 2-40. PP-7197AA FLIR POWER SUPPLY FAILURE RATE WORKSHEET

Qty	Type	V Stress	Cooled by moving air, 6 lb/kW pd, $80^{o}F$ Tmax air in, $+40^{o}F$ rise in air temp, $+20^{o}F$ rise from air to mounting Mounting surface = $140^{o}F = 60^{o}C$.				V Stress	Cooled by $5^{o}C$ cold plate.			
			P Stress	Temp ^{o}C	λ/Unit	λ Total		P Stress	Temp ^{o}C	λ/Unit	λ Total
10	Pwr NPN (JAN)	0.6	0.1	90	1.5675	15.675	0.6	0.1	40	0.8910	8.910
1	Pwr PNP (JAN)	0.6	0.1	80	1.2870	1.287	0.6	>0.1	30	0.6930	0.693
23	Sig NPN (JAN)	0.4	0.1	70	0.2700	6.210	0.4	>0.1	20	0.1548	3.560
14	Rectifier (JTX)	0.4	0.2	110	0.6720	9.408	0.4	0.2	60	0.1344	1.882
10	Hi speed Diode, Pwr. (JAN)	0.6	0.2	110	0.5600	5.600	0.6	0.2	60	0.2188	2.188
30	Sig Diode (JAN)	0.3	0.1	70	0.2013	6.039	0.3	>0.1	20	0.1050	3.150
3	I.C. Lin (JAN)	-	-	95	2.9000	8.700	-	-	45	0.9816	2.945
77	RCR's	-	0.1	70	0.1037	0.277	-	0.1	20	0.0004	0.031
10	RNR's	-	0.1	70	0.0013	0.013	-	0.1	20	0.0008	0.008
10	RWR's	-	0.2	90	0.0426	0.426	-	0.2	40	0.0270	0.270
2	RTR	-	0.1	70	0.1260	0.252	-	0.1	20	0.0832	0.166
38	Caps Tant.	0.6	-	70	0.1000	3.800	0.6	-	20	0.0600	2.280
8	Caps Ceramic	0.4	-	70	0.0312	0.250	0.4	-	20	0.0272	0.218
8	Chokes	-	-	110	0.1240	0.992	-	-	60	0.0840	0.672
4	Low Power Xform.	-	-	110	0.1240	0.496	-	-	60	0.0840	0.336
1	Output Xform.	-	-	110	0.1240	0.124	-	-	60	0.0840	0.084
						$\Sigma\lambda = 59.549$					$\Sigma\lambda = 27.393$

Data for the recent calendar year available are shown in Table 2-41.

A modifying factor of 2:1 was applied to the observed data to convert from MFHBMA to MTBMA. Additionally, a 4:1 factor was applied to the observed data to allow direct comparison between the 3M data and the 270 Vdc power supply predictions. This 4 to 1 factor was applied to account for "non-primary functional failure" events in the reported data, such as induced failures, secondary failures and unjustified rework, thus, enabling the conversion from MTBMA to an equipment MTBF.

The MTBF value for the existing representative 400 HZ power supplies obtained under these ground rules was 502 hours. These results are summarized in Table 2-42.

Review of these data show that a 2-to-1 improvement factor can be obtained by using 270 Vdc power supplies in the S-3A without changing the existing rack cooling, while a 5-to-1 improvement results from application of Freon vapor cold plate methodology.

To develop parameters applicable to LCC computation, it is necessary to extend the MTBF values obtained for the representative power supplies to the entire aircraft power supply complement and then to convert the MTBF prediction to equivalent MTBMA values. First, it was established that the power supplies contained in the 7 subsystem study group represents approximately 55 percent of the total S-3A population. It was further established that the total maintenance actions performed on this study group accounted for about 56 percent of the total aircraft power supply maintenance actions. This close correlation permitted valid extension of the calculated reliability data to the entire power supply population, with the results shown in Table 2-43.

In converting these values to MTBMA, the previously used factor of 4-to-1 was again applied with the results shown in Table 2-44. Also shown are the equivalent MFHBMA values, representative of the parameters as would be displayed in the 3M data system.

TABLE 2-41. S-3A POWER SUPPLY FAILURE HISTORY
CALENDAR YEAR 1977 (SHEET 1 OF 4)

REPORTED FLT HRS = 59619.0

Work Unit Code	Equip.	Description	Qty/AC	M.A.	M.A. Per Flt Hr	$MFHBMA_I$	Rank
56711Q0	AACS, AYN-5	Power Supply Module, PS-1	1	43	0.000721	1386	6
56711R0		Power Supply Module, PS-2	1	29	0.000486	2056	10
612617	HF R/T	Power Supply A7	1	5	0.000084	11924	
612622	HF PA	Power Supply A2	1	110	0.001845	542	2
612634	HF CPLR	Power Supply A4	1	12	0.000201	4968	
727H19	APS-116	Low Voltage Regulators 1A9	1	1	0.000017	59619	
727H1D	Programmer	Unregulated Pwr. Supply 1A13	1	24	0.000403	2484	
727H1E	Pwr. Supply	Voltage Reg. Heat Sink 1A14	1	10	0.000168	5962	
727H1F		Servo Amp. Pwr. Supply 1A15	1	4	0.000067	14905	
727H1G		Azimuth Pwr. Supply 1A16	1	34	0.000570	1754	9
73B161	AYK-10, GPDC	Switching Reg. Type A, A1	1	2	0.000034	29810	
73B162	PP-6679	Switching Reg. Type A, A2	1	3	0.000050	19873	
73B166		Switching Reg. Type B, A3	1	4	0.000067	14905	
73B170	PP-6675	Power Supply, GPDC	2	33	0.000277	3613	
73B180	PP-6677	Power Supply, GPDC	2	36	0.000302	3312	
73B1A	PP-6676	Power Supply, GPDC	2	16	0.000134	7452	
73B1C1	PP-6678	Switching Reg. Type A, A1	1	4	0.000067	14905	
73B1C2		Switching Reg. Type A, A2	1	1	0.000017	59619	
73B1C3		Switching Reg. Type B, A3	1	2	0.000034	29810	
73B31W	OL-82 ADP	+5V/+38V Pwr. Inverter A30	1	57	0.000956	1046	3
73B31Y	CV-2882	-5V Regulator A32	1	3	0.000050	19873	
73B31Z	Sig. Data	+12V Regulator A33	1	1	0.000017	59619	
73B321	Converter	-12V Regulator A34	1	5	0.000084	11924	

TABLE 2-41. S-3A POWER SUPPLY FAILURE HISTORY
CALENDAR YEAR 1977 (SHEET 2 OF 4)

REPORTED FLT HRS = 59619.0

Work Unit Code	Equip.	Description	Qty/ AC	M.A.	M.A. Per Flt Hr	$MFHBMA_I$	Rank
73B344	OL-82 ADP	+5V Pwr. Inverter A38	1	21	0.000352	2839	
73B345	SG-962	Protect/Bite PS Control A39	1	50	0.000839	1192	5
73B347	Spectrum	+15V Regulator A41	1	-0-	-	-	
73B348	Analyzer	-15V Regulator A42	1	3	0.000050	19873	
73B34A		EMI Filter Assy. FL1	1	1	0.000017	59619	
73B364	OL-82 ADP	+5V Pwr. Inverter A38	1	20	0.000335	2981	
73B365	CV-2883	Protect/Bite PS Control A39	1	38	0.000637	1569	7
73B367	Spectrum	+15V Regulator A41	1	4	0.000067	14905	
73B368	Analyzer	-15V Regulator A42	1	-0-	-	-	
73B36A		EMI Filter Assy. FL1	1	-0-	-	-	
73B3B2	OL-82 ADP	+5V Regulator A2	1	-0-	-	-	
73B3B3	PP-6671	Internal Voltage Reg A3	1	3	0.000050	19873	
73B3B4	Drum	+15V Regulator A4	1	2	0.000034	29810	
73B3B5	Power	+12V/-5V Regulator A5	1	2	0.000034	29810	
73B3B6	Supply	Internal Voltage Reg A6	1	-0-	-	-	
73B3B7		+12V/-5V Regulator A7	1	1	0.000017	59619	
73B3B8		Static Converter A8	1	16	0.000268	3726	
73B3B9		Static Converter A9	1	15	0.000252	3975	
73B3E9	OL-82 ADP	+5V/+38V Pwr. Inverter A42	2	34	0.000285	3507	
73B3EB	CP-1140 Sonar	+15V Regulator A44	2	13	0.000109	9172	
73B3EC	Data Comp.	-15V Regulator A45	2	5	0.000042	23848	
73B43B	ASA-82	Voltage Regulator No. 1, VR1	2	54	0.000453	2208	
73B43C	IP-1054	Voltage Regulator No. 2, VR2	2	2	0.000017	59619	
73B43D	TACCO/SENSO	Voltage Regulator No. 3, VR3	2	17	0.000143	7014	
73B43E	Tactical	Voltage Regulator No. 4, VR4	2	5	0.000042	23848	
73B43K	Indicator	High Voltage Pwr. Supply	2	1	0.000008	119238	

TABLE 2-41. S-3A POWER SUPPLY FAILURE HISTORY
CALENDAR YEAR 1977 (SHEET 3 OF 4)

REPORTED FLT HRS = 59619.0

Work Unit Code	Equip.	Description	Qty/ AC	M.A.	M.A. Per Flt Hr	$MFHBMA_I$	Rank
73B47A	ASA-82	+15V Regulator, VR1	1	16	0.000268	3726	
73B47B	CV-2806	+5V Regulator, VR2	1	120	0.002013	497	1
73B47C	D/A	-15V Regulator, VR3	1	13	0.000218	4586	
73B47D	Converter	+15V Regulator, VR4	1	2	0.000034	29810	
73B47E	(DGU)	+5V Regulator, VR5	1	55	0.000923	1084	4
73B47F		-15V Regulator, VR6	1	3	0.000050	19873	
73B47G		+15V Regulator, VR7	1	1	0.000017	59619	
73B47H		+5V Regulator, VR8	1	35	0.000587	1703	8
73B47J		-15V Regulator, VR9	1	1	0.000017	59619	
73B47K		+15V Regulator, VR10	1	3	0.000050	19873	
73B47L		+5V Regulator, VR11	1	24	0.000403	2484	
73B47M		-15V Regulator, VR12	1	2	0.000034	29810	
773141	OR-89	Video Reg. Pwr. Supply 2A1	1	1			
773142	FLIR	Video Reg. Pwr. Supply 2A2	1	2	(See WUC		
773143	PP-6611	Video Reg. Pwr. Supply 2A3	1	3	773171-		
773144	Video Conv/	Video Reg. Pwr. Supply 2A4	1	-0-	773170)		
773145	Pwr. Supply	Camera Reg. Module 2A5	1	1			
773146		+/- 15V Assy. 2A6	1	2			
	(Superseded By PP-7197)						
773155	C-8759	+/- 15V Regulator 3A6	1	8	0.000134	7452	
773156	FLIR Control	+/- 30V Bridge 3A7	1	3	0.000050	19873	
77315B	Converter	5V Regulator 3A14	1	10	0.000168	5962	

TABLE 2-41. S-3A POWER SUPPLY FAILURE HISTORY
CALENDAR YEAR 1977 (SHEET 4 OF 4)

REPORTED FLT HRS = 59619.0

Work Unit Code	Equip.	Description	Qty/ AC	M.A.	M.A. Per Flt Hr	$MFHBMA_I$	Rank
773171	OR-89	Video Reg. Pwr. Supply 2A1	1	1	0.000034	29810	
773172	FLIR	Video Reg. Pwr. Supply 2A2	1	-0-	0.000034	29810	
773173	PP-7197	Video Reg. Pwr. Supply 2A3	1	-0-	0.000050	19873	
773174	Video Conv/	Video Reg. Pwr. Supply 2A4	1	-0-	-	-	
773175	Pwr. Supply	Camera Reg. Module 2A5	1	2	0.000050	19873	
773176		+/- 15V Assy. 2A6	1	5	0.000117	8517	
	(Replaces PP-6611)						
		Total	87	1059	0.015953	62.7	
		Average			0.000197	5077	

M.A. = Total I-Level Maintenance Actions

$MFHBMA_I$ = Mean Flight Hours Between I-Level Maintenance Actions

TABLE 2-42. RELIABILITY ESTIMATES - REPRESENTATIVE POWER SUPPLY GROUPS

POWER SUPPLY CONFIGURATION		MTBF
Existing S-3A Power Supplies, Forced Air Cooling		502
Proposed 270 Vdc Power Supplies	Forced Air Cooling	1022
	5^{o} Cold Plate Cooling	2501

TABLE 2-43. RELIABILITY ESTIMATES - TOTAL S-3A POWER SUPPLY COMPLEMENT

POWER SUPPLY CONFIGURATION		MTBF
Existing S-3A Power Supplies, Forced Air Cooling		276
Proposed 270 Vdc Power Supplies	Forced Air Cooling	563
	5^{o} Cold Plate Cooling	1378

TABLE 2-44. MAINTENANCE ESTIMATES - TOTAL S-3A POWER SUPPLY COMPLEMENT

POWER SUPPLY CONFIGURATION		MTBMA	MFHBMA
Existing S-3A Power Supplies, Forced Air Cooling		69	35
Proposed 270 Vdc Power Supplies	Forced Air Cooling	141	70
	5^{o} Cold Plate Cooling	345	172

In conclusion, the reported mean flight hours between maintenance actions for the entire S-3A power supply complement, exclusive of mechanical components, connectors, and wiring, will demonstrate an improvement of 35 MFHBMA with 270 Vdc power supplies, retaining existing S-3A cooling techniques. An improvement of 137 MFHBMA will result if Freon/Vapor cycle cold plate cooling is also employed.

2.3 ENVIRONMENTAL CONTROL SYSTEM

The ECS employed on the S-3A is a simple, ram air augmented, air cycle type system which basically consists of a compression/expansion turbine, heat exchangers, water separator and air distribution system/ducting. Engine bleed air, augmented by ram air, is the source of air supply.

The S-3A ECS was first analyzed to establish the potential weight reductions made possible with 270 Vdc primary aircraft power technology. Following this analysis, the existing air cycle ECS was theoretically replaced with a Freon vapor cycle ECS to determine what further weight reductions could be realized.

2.3.1 Air Cycle Environmental Control System

The current S-3A ECS cooling capacity was established based upon the cooling requirements of the forward and aft cabins. This capacity was minimized by utilizing cabin exhaust air, which is normally exhausted overboard, to cool aft cabin avionics. Cooling air supplied to the forward cabin at 60°F to 80°F provides the necessary cooling for flight and crew station comfort and cools those avionic equipments and instruments located therein. The air is then drawn through the aft cabin avionic boxes, thus providing their required cooling prior to being exhausted overboard. The avionics are so located that the forward and aft cabin cooling loads are approximately equal.

2.3.2 Air Distribution System

The conditioned air distribution system, Figure 2-16, delivers approximately 60 percent of the conditioned air to the flight station and 40 percent to the crew stations. All cabin air is exhausted overboard via the right and left weapons bays and underfloor sonobuoy bays, except for a maximum air flow of 1.5 pound per minute to the APU compartment and cabin leakage, Figure 2-17.

2.3.3 400 Hz/270 Vdc Evaluation

The power supplies from seven avionic subsystems were evaluated to determine the impact of 270 Vdc technology. The efficiencies of 400 Hz and

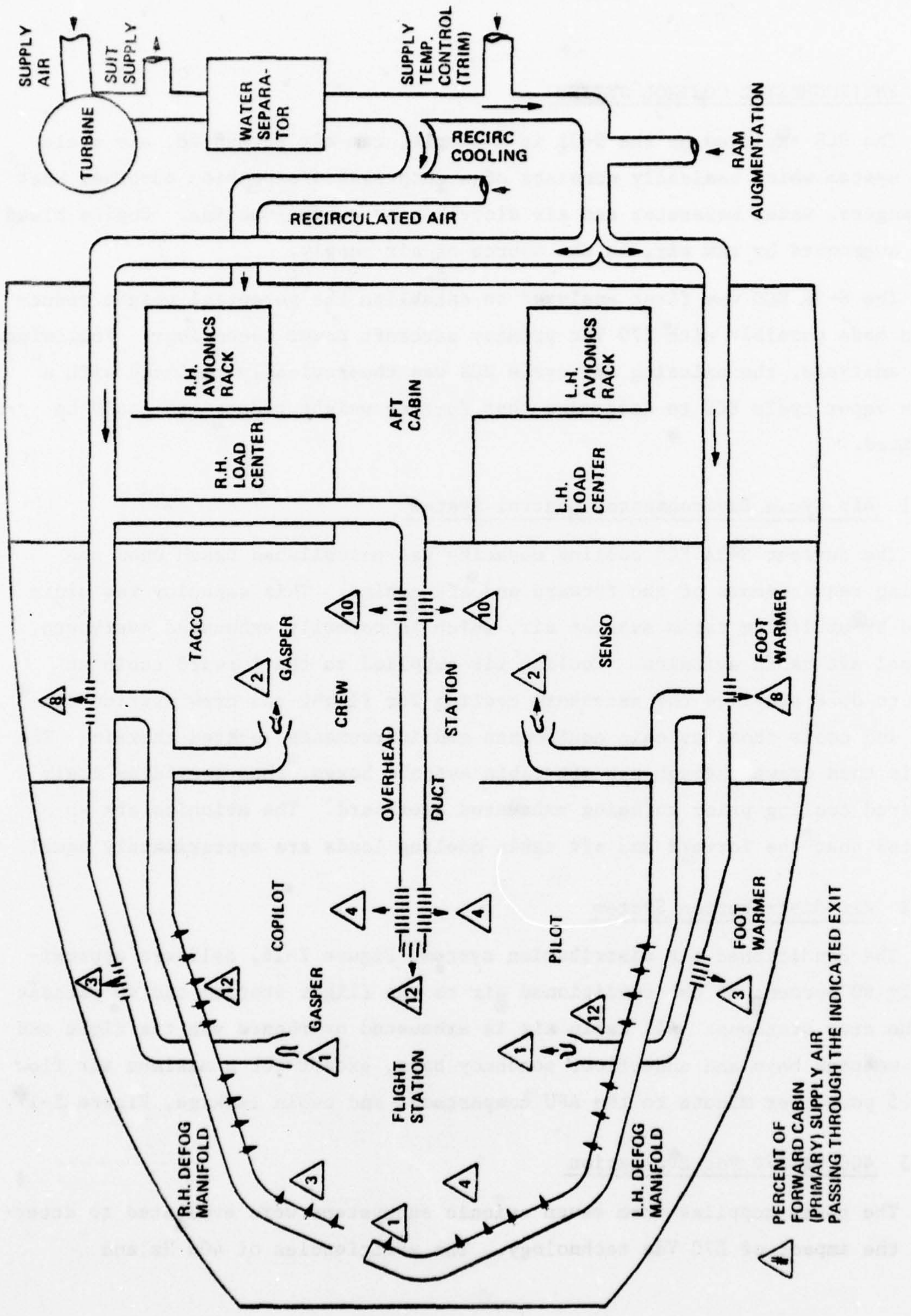


Figure 2-16. S-3A Conditioned Air Distribution System

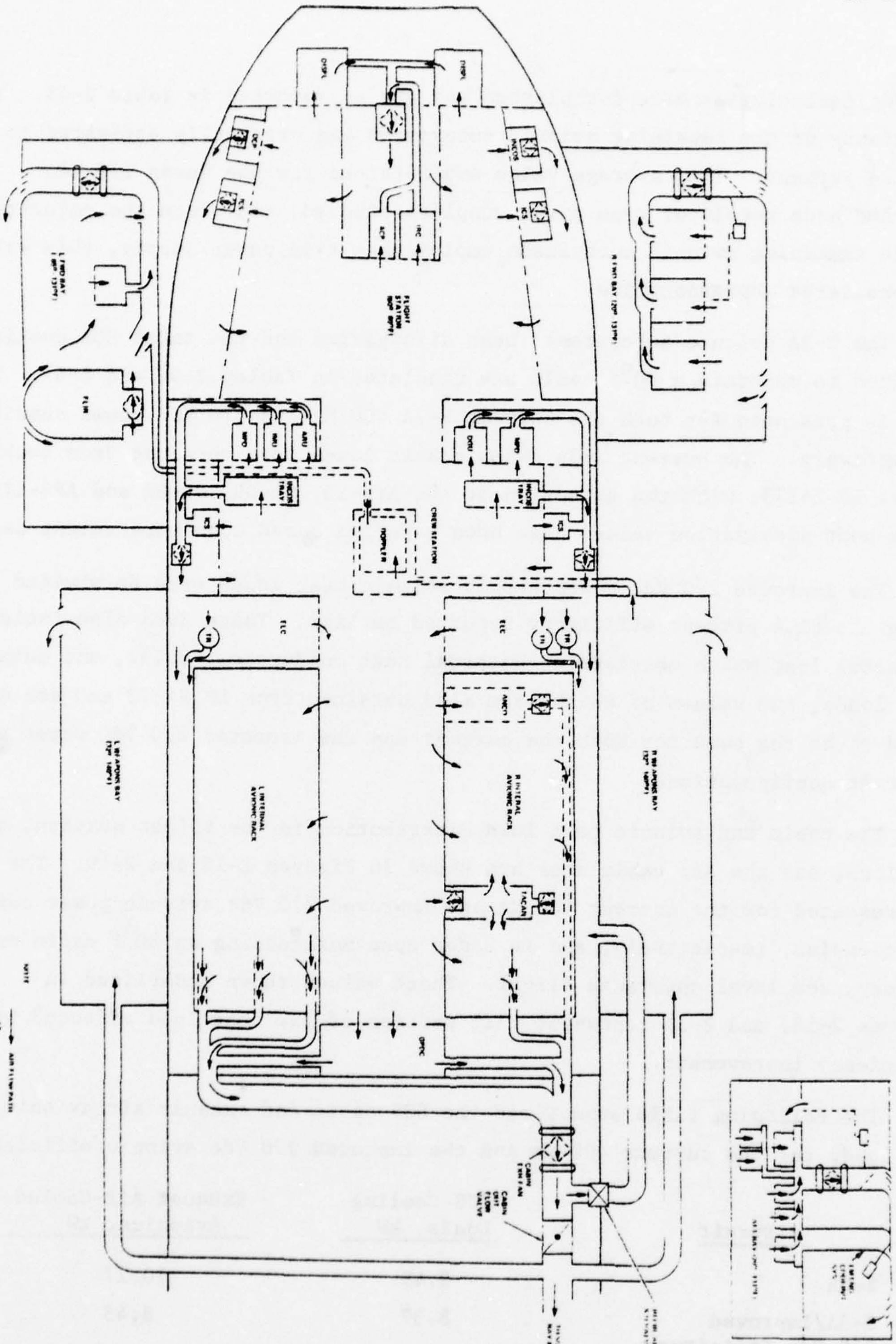


Figure 2-17. S-3A Cabin Exhaust System

270 Vdc technologies were established and are as reported in Table 2-45. The efficiency of the remaining avionic subsystems was originally estimated to be 81.4 percent. This average value was obtained for the seven 270 Vdc switched mode regulator type power supplies studied, and since the majority of the remaining avionic subsystems employ this type power supply, this value is considered representative.

The S-3A avionic subsystems' heat dissipation and the total ECS cooling required to maintain a 80°F cabin are tabulated in Tables 2-46 and 2-47. The data is presented for both the current S-3A 400 Hz and 270 Vdc power supplies respectively. The current S-3A avionic heat loads were obtained from Lockheed Report LR 24573, with the exception of the AYK-10, OR-89, OL-82 and APS-116, whose heat dissipation values have been reported based upon more recent data.

The improved 270 Vdc power supply avionic heat loads were determined using the 81.4 percent efficiency reported earlier. These data also include the hotel load which consists of external heat conduction, solar, and metabolic heat loads, the values of which were also obtained from LR 24573 and are assumed to be the same for both the current and the improved 270 Vdc power supply aircraft configurations.

The cabin and avionic heat load distribution in the flight station, crew stations, and the aft cabin area are shown in Figures 2-18 and 2-19. The data is presented for the current 400 Hz and improved 270 Vdc avionic power supply efficiencies, respectively, and is based upon maintaining an 80°F cabin on a hot day, sea level endurance flight. Those values shown underlined in Figures 2-18, and 2-19 represent that portion of the heat load affected by the efficiency improvement.

The following table summarizes the ECS cabin and exhaust air avionic cooling loads for the current 400 Hz and the improved 270 Vdc avionic efficiencies:

Aircraft	ECS Cooling Loads, kW	Exhaust Air-Cooled Avionics, kW
S-3A	9.49	10.17
S-3A/Improved 270 Vdc Efficiency	8.37	8.45
Percentage Improvement	11.8	16.9

TABLE 2-45. POWER SUPPLY EFFICIENCY/DISSIPATION

Equipment	Efficiency 400Hz	Efficiency 270 Vdc	Dissipation 400 Hz	Dissipation 270 Vdc
ASA-82	55.93%	86.23%	1356.5	274.3
IP-1051	55.29%	84.54%	195.4	44.2
IP-1052	54.75%	85.71%	119.0	24.0
IP-1053	60.67%	88.83%	217.1	42.1
IP-1054	60.75%	88.73%	226.5	44.5
CV-2806	44.64%	80.00%	372.0	75.0
OL-82	67.96%	75.44%	1348.5	931.3
CP-1140	71.92%	75.83%	163.4	133.4
CV-2882	74.93%	80.81%	136.0	96.5
SG-962	66.56%	74.42%	254.3	167.8
PP-6671	59.97%	74.09%	273.0	143.0
AYK-10	62.88%	71.42%	694.9	507.5
PP-6679	87.44%	94.69%	123.0	45.0
PP-6678	87.01%	94.29%	116.0	45.7
PP-6675	70.85%	71.72%	72.0	69.0
PP-6676	73.51%	75.18%	57.2	52.4
PP-6677	72.57%	74.21%	107.8	99.1
AYN-5	75.66%	77.33%	44.7	40.8
OR-89				
C-8759	58.66%	75.85%	105.0	42.4
PP-7197	64.89%	78.45%	349.0	173.2
IP-1069/1214	40.61%	84.32%	29.1	3.7
ARC-153				
AM-6384	61.84%	72.91%	829.5	499.4
CU-1985	52.80%	82.14%	20.6	5.0
PT-1016				
APS-116				
PP-6633	75.73%	79.71%	225.0	178.7
T-1203	89.56%	89.90%	353.3	279.4

TABLE 2-46. WATT DISSIPATION - PRESENT S-3A

Equipment	Total	Fwd Cabin	Aft Cabin	Exhaust Air	Unpressurized Area
Avionics Subsystem:					
AYK-10	1872	0	262	1610	0
ASQ-147	565	313	75	107	70
ASA-82	3078	2318	760	0	0
RD-348/ASH	42	0	6	36	0
CV-2881/AS	82	0	11	71	0
ASA-65A	106	30	76	0	0
ASQ-81	114	23	63	0	28
OR-89/AA	3192	0	111	685	2396
ALR-47	349	0	36	219	94
APS-116	3320	0	51	314	2955
OU-78/AP	586	3	51	311	221
APX-76	203	8	0	0	195
APX-72	124	4	0	0	120
OA8770/ASH	63	0	0	0	63
ARN-83	33	0	33	0	0
ARA-50	55	0	0	0	55
APN-201	73	24	0	0	49
OD-59A	343	105	33	205	0
AYN-5A	220	0	31	189	0
APN-200	142	0	0	0	142
ARN-84	350	3	347	0	0
ARS-2	78	0	11	67	0
ASN-92	540	97	110	333	0
ASA-84	265	54	30	181	0
ARA-63	166	2	0	0	164
ASN-107	139	0	56	83	0
ASW-33	449	47	51	312	39
APN-202	68	4	0	0	64
ASW-25	69	15	0	0	54
CV-2830/AYC	114	0	0	0	114
ARC-153A	1790	0	0	0	1790
ARC-156A	1393	7	0	0	1386
OK-248A/AI	662	277	29	0	356
TSEC/KY-28	33	0	33	0	0
TSEC/KG-40	50	0	50	0	0

TABLE 2-46. WATT DISSIPATION - PRESENT S-3A (Cont'd)

Equipment	Total	Fwd Cabin	Aft Cabin	Exhaust Air	Unpressurized Area
Avionics Subsystem:					
OL82A	4211	2	589	3620	0
ARR-76	216	0	27	168	21
ASH-27A	275	0	38	237	0
AWB-2	204	32	172	0	0
TD-1146/AS	14	14	0	0	0
C-8057/ARC	3	3	0	0	0
Subtotal	25651	3385	3142	8748	10376
Instrument & Misc Electrical Equip't (Incl Fans)	10890	1717	44	0	9129
Electrical Load Center	1859	0	1859	0	0
Hotel Load (80°F Cabin)	-	4385	283	-	-
Total ECS Requirement	-	9487	-	-	-

TABLE 2-47. - WATT DISSIPATION - IMPROVED S-3A 270 Vdc POWER SUPPLIES

Equipment	Total	Fwd Cabin	Aft Cabin	Exhaust Air	Unpressurized Area
Avionics Subsystem:					
AYK-10	1648	0	231	1417	0
ASQ-147	397	220	53	75	49
ASA-82	2004	1516	488	0	0
RD-348/AS	29	0	4	25	0
CV-2881/AS	58	0	8	50	0
ASA-65A	75	21	54	0	0
ASQ-81	80	16	44	0	20
OR-89/AA	2932	0	79	482	2371
ALR-47	245	0	25	154	66
APS-116	3157	0	45	277	2835
OU-78/AP	478	2	36	219	221
APX-76	143	6	0	0	137
APX-72	87	3	0	0	84
0A8770/ASH	44	0	0	0	44
ARN-83	23	0	23	0	0
ARA-50	39	0	0	0	39
ARN-201	51	17	0	0	34
OD-59A	241	74	23	144	0
AYN-5A	218	0	31	187	0
APN-200	100	0	0	0	100
ARB-84	246	2	244	0	0
ARS-2	55	0	8	47	0
ASN-92	380	68	78	234	0
ASA-84	186	38	21	127	0
ARA-63	116	1	0	0	115
ASN-107	98	0	39	59	0
ASW-33	316	33	36	220	27
APN-202	48	3	0	0	45
ASW-25	49	11	0	0	38
CV-2830/AYC	80	0	0	0	80
ARC-153A	1145	0	0	0	1445
ARC-156A	980	5	0	0	975
OK-248A/AI	465	195	20	0	250
TSEC/KY-28	23	0	23	0	0
TSEC/KG-40	35	0	35	0	0
OL-82A	3794	1	531	3261	0
ARR-76	152	0	19	118	15
ASH-27A	194	0	27	167	0
AWB-2	144	22	122	0	0
TD-1146/AS	10	10	0	0	0
C-8057/ARC	2	2	0	0	8990

TABLE 2-47. - WATT DISSIPATION - IMPROVED S-3A 270 Vdc POWER SUPPLIES (Cont'd)

Equipment	Total	Fwd Cabin	Aft Cabin	Exhaust Air	Unpressurized Area
Avionics Subsystem:					
Subtotal	20847	2266	2347	7263	8990
Instrument & Misc Electrical Equip't (Incl Fans)	10890	1717	44	7910	
Electrical Load Center	1859	0	1859	0	0
Hotel Load (80^{o}F Cabin)	-	4385	-283	0	-
Total ECS Requirement	-	8368	-	-	-

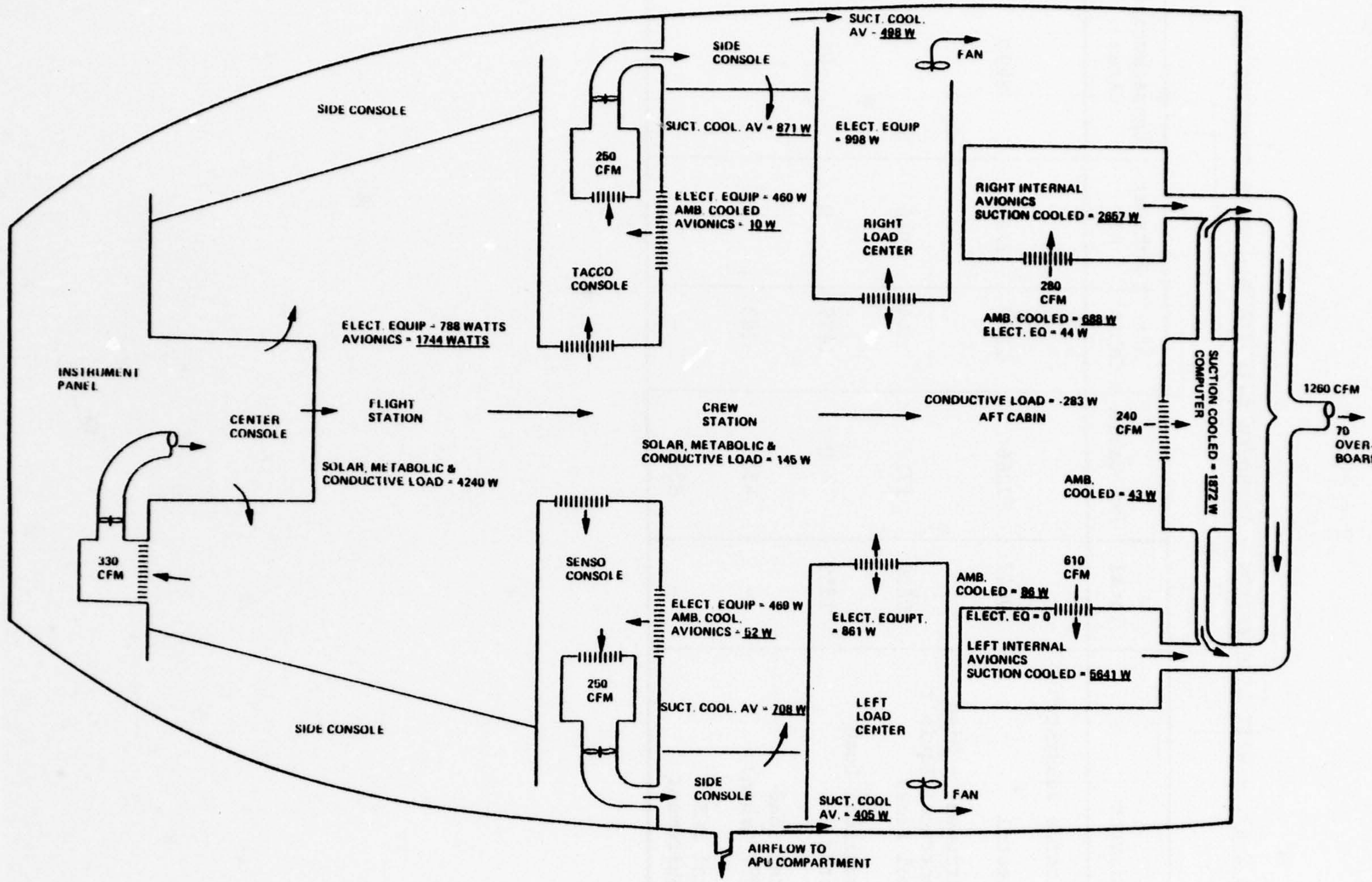


Figure 2-18. Airflow Paths Through the Pressurized Cabin and Cabin Heat Loads for S-3A

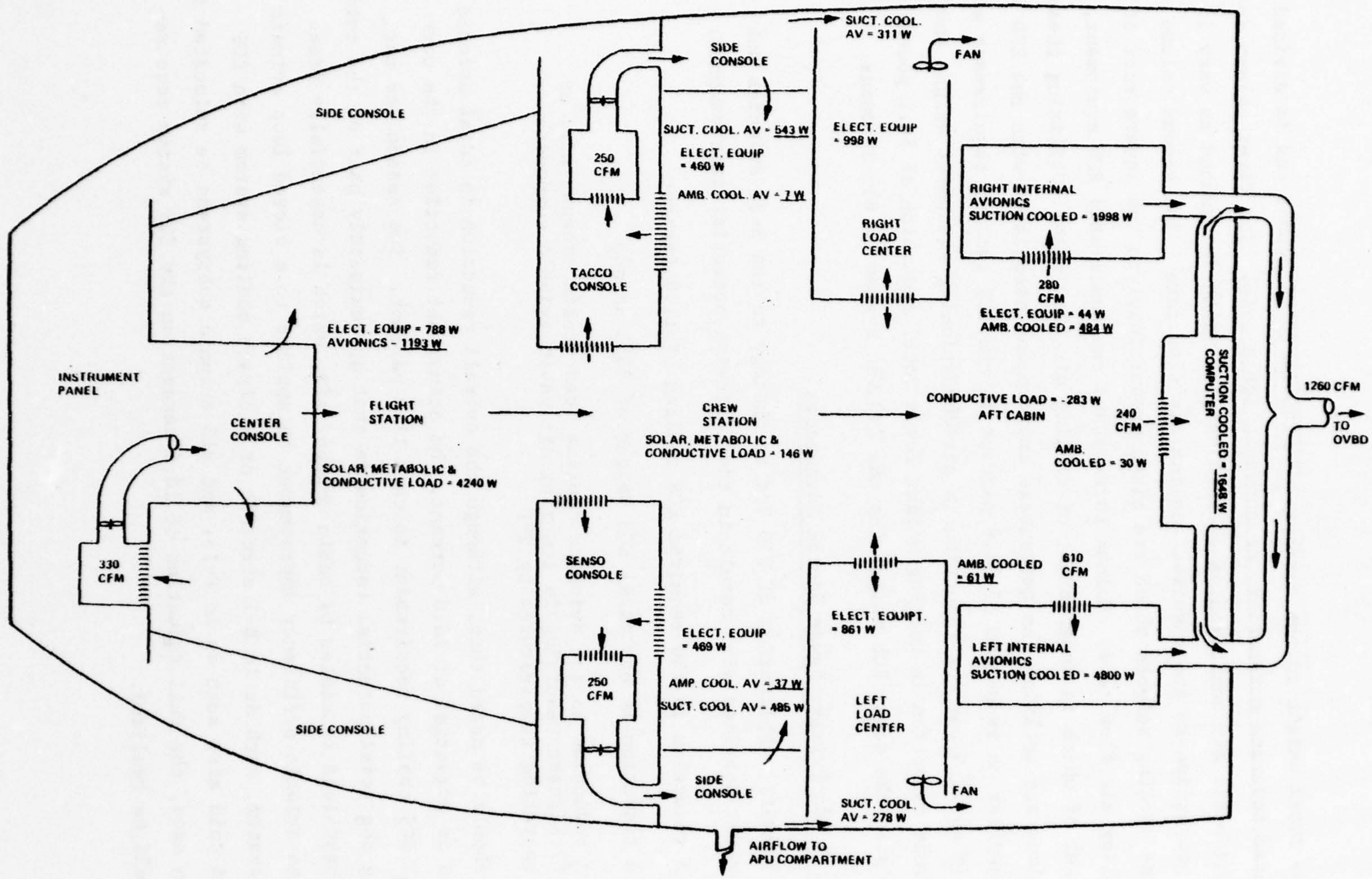


Figure 2-19. Airflow Paths Through the Pressurized Cabin and Cabin Heat Load for S-3A with Improved Avionic System Efficiency

The total weight of the current S-3A ECS is 691.4 pounds and is divided into three separate categories, as shown in Table 2-48. The first column depicts the basic air conditioning package weight, which is assumed to vary in direct proportion to the required cooling air flow rate. The second column shows the ducting weights which are sized proportional to the square root of the cooling air flow rate. Column three shows the associated ECS equipment, the weight of which is independent of cooling air flow rate. Utilizing these proportions and applying the percentage improvement associated with the 270 Vdc power supplies, a reduction of 11.8 percent in the ECS cooling requirement will result in an 11.8 percent reduction in air conditioning equipment weight and a 6 percent reduction in ducting weight for a total reduction of 56.2 pounds. This reduces the total ECS weight for the 270 Vdc system to 635.2 pounds.

2.3.4 270 Vdc Primary Power Source Advantages

In summary, application of 270 Vdc technology to the S-3A avionics subsystems power supplies will result in the following potential improvements:

- A reduction in the required ECS cooling of 11.8 percent
- A reduction in the total ECS weight of 56.2 pounds
- A reduction in the avionics cooling load (cabin exhaust air) of 17 percent resulting in lowering aft cabin avionic component operating temperatures by 2°F

It should be noted that, although the overall reduction in total avionic heat load is potential of 18.6 percent, the actual net reduction in the current S-3A ECS cooling requirement is only 11.8 percent. The reason for not realizing the total potential reduction is that approximately half of the total avionic heat load is cooled by cabin exhaust air, which is essentially free. Should the avionic efficiency improvement be applied to a closed loop avionic cooling system, such as in B-1 aircraft or a direct cooling system with ECS delivered cold air, such as in F-14, and all avionic subsystems be relocated in the cabin area, the full reduction of 18.6 percent on the ECS system requirements could be realized.

TABLE 2-48. ECS WEIGHTS

Aircraft	Equipment	Air Conditioning, lbs	Ducting & Ass'd Equipment., lbs	Fixed Weight Equipment, lbs
S-3A	Heat Exchanger	92.8		
	Turbine	33.0		
	Fans	55.5		
	Water Separator	14.3		
	Scoop			13.5
	Ducting		272.3	
	Valves	66.7		7.0
	Plumbing	16.3		
	Gaspers			3.1
	Ground Connection			1.9
	Insolation		24.9	
	Controls -			
	Electric			22.3
	Pneumatic			9.7
	Supports	29.0	29.1	
	Subtotal	307.6	326.3	57.5
	Total	691.4		
S-3A Improved P.S.	Subtotal	271.3	306.4	57.5
	Total	635.2		

2.3.5 Vapor Cycle Environmental Control System

The major advantage of a vapor cycle ECS over an air cycle ECS is the relative coefficient of performance, the air cycle being approximately 0.5 as compared to approximately 2.0 for the vapor cycle system. Utilization of the vapor cycle system in the S-3A would not only enable more efficient cooling by virtue of the 4 to 1 performance coefficient but, as described later in this section, will also reduce the avionic component junction temperatures.

The current S-3A ECS, which utilizes a simple air cycle system, fulfills both cabin air conditioning and pressurization requirements. Should a vapor cycle ECS be employed, the vapor cycle system, having no cabin pressurization capability, would fulfill only the air conditioning requirement. Engine bleed air would be employed to accomplish the necessary pressurization.

The vapor cycle ECS is a closed loop system in which the liquid Freon is recirculated, first through an expansion valve and into an evaporator where, utilizing this Freon's latent heat of vaporization, heat is absorbed from the cabin and avionics air, Figure 2-20. The gaseous Freon is then routed through a compressor where it is compressed to a liquid form, and passed through a condenser where the absorbed heat, along with the heat of compression, is withdrawn and ejected overboard. The compressor is a centrifugal type, driven by a high speed 270 Vdc electrical motor.

The engine bleed air, used for pressurization, is cooled to the required temperature via a ram air cooled heat exchanger prior to being discharged into the cabin. In a cold ambient environment, the cold ram air flow through the heat exchanger is throttled down (reduced), thus allowing the bleed air to fulfill a portion of the cabin heating requirement. The remainder of the required cabin heating will be supplied by an electrical heater which, as will be described later, is also being used for air dehumidification.

In the proposed S-3A vapor cycle ECS, all the cockpit instruments, non-avionic electrical equipment and the left and right-hand electrical load centers will remain unchanged and cooled by the natural convection process. The heat generated by these equipments dissipates into the cabin and is subsequently cooled by the cabin Freon evaporator. Cold plate cooled avionic

equipment will be left intact with the exception of their air cooled cold plate/fin heat exchangers which will be replaced with Freon plate/tube evaporators. In the case of the ambient-cooled avionics, the Freon will pass through tubing welded to each heat sink within the unit. Quick disconnect couplings will be installed to allow a leak-free system for engaging and disengaging the unit's Freon lines. Cooling flow paths to the avionic equipments will be connected in parallel, the flow to each unit being controlled, as required, to provide optimum cooling by a fixed size orifice. Freon exhaust from the avionic boxes will be routed through the electrical load centers to allow further evaporation of any remaining liquid Freon which may exist as the result of avionic heat load fluctuations, thus ensuring maximum usage of the total ECS cooling capability. The avionic cold plate temperatures will be maintained at $40^{o}F$ to $45^{o}F$ as compared to current S-3A cold plate temperatures of $100^{o}F$ to $140^{o}F$.

Dehumidification of the aircraft interior will be continuously accomplished by utilization of the cabin evaporator/fan/electrical heater. After turning on the fan and heater, the vapor cycle system is energized and provides an evaporator surface temperature of $40^{o}F$ to $45^{o}F$. As the cabin air is drawn through the evaporator by the fan, the moisture in the air is condensed on the evaporator surface and drained off to the exterior of the aircraft. The dried air is then reheated as required to maintain a 80 to $90^{o}F$ temperature and discharged back into the cabin where the evaporation and drying cycle is repeated continuously. During ground operation and after an initial drying out period, the required cabin ventilation is provided by utilization of the auxiliary ventilation valve and the cabin ventilation fan.

2.3.5.1 Vapor Cycle ECS Weight Comparison

Total ECS cooling requirements for an S-3A aircraft which employs both the Freon vapor cycle ECS and the improved 270 Vdc power supplies are presented in Table 2-49. Cooling loads are shown for both cabin evaporator and Freon cold plates and include those loads associated with the convection and cold plate-cooled avionics, electrical equipment and load centers, fans and hotel loads. Also shown are the loads for those avionics located in the

TABLE 2-49. VAPOR CYCLE COOLING LOAD

Equipment	Cabin Evap'r Load, W	S-3A IMP. P.S. Freon Coldplate Load, W	Unpress Area Load, W
Avionics	484	11391	8990
Elect. Equipt	514		7910
Ventilation Load	1771		
Evaporator Fan	347		
Electrical Load Centers	1859		
Hotel Loads	4102		
Subtotal	9077	11391	16900
Total Vapor Cycle Requirement		20468	
Ram Air Cooling Load	0	0	16900

external bays which are cooled by outside ambient air, unchanged from the current S-3A.

Unlike the S-3A air cycle ECS, where the aft cabin avionics are cooled by forward cabin exhaust air and are not included in the ECS cooling requirement, the vapor cycle ECS cooling requirement includes all avionic and electrical equipment whose heat is dissipated in the pressurized cabin. As a result, the ECS load for the S-3A aircraft with improved 270 Vdc power supplies and the vapor cycle ECS is 20.5 kW as compared to 8.4 kW for the same S-3A with the air cycle ECS (Ref Table 2.47). The required electrical input power for the vapor cycle ECS is 15.2 kW.

The total weight of the proposed 20.5 kW cooling capacity vapor cycle ECS in the S-3A aircraft using the 270 Vdc power supplies is shown in Table 2-50. These data include those weight elements associated with the (1) vapor cycle air conditioning package, (2) Freon, (3) supply and exhaust lines, (4) insulation, (5) electrical and flow control systems and valves, (6) cabin evaporation, and (7) the ground ventilation and cabin pressurization systems. The total system weight of 373.4 pounds compares to 635.2 pounds

TABLE 2-50. VAPOR CYCLE ECS WEIGHT

Equipment	S-3A IMP. P.S., lbs
Compressor/Condenser Package Including:	107.7
compressor, condensor, condenser fan, condenser shutters, subcooler, drier, dual control valve, suction thr. valve, receiver, R-114 charge tube and fitting, press control	
Comp./Cond. Packaging, Misc.	10.1
Evaporator/Fan/Heater Including:	30.3
evaporator, fan, elect. heater, air filter, tube and fitting, wiring, press switches, system thermal switch, fault ind. unit	
Freon/Line/Valve	16.5
Freon Line Insulation	7.8
Support and Bracket	12.1
Electrical Controls	11.9
Freon Control Valves	26.2
Condenser Cooling Duct	35.6
Cabin Evap. Air Dist. Duct	45.8
Pressurization System (bleed airline and heat exchanger)	13.8
Aux Vent (scoop, duct, valves and emerg. hatch)	17.8
Ground Vent Fan and Duct	6.5
External Bay Cooling Fans	24.3
Cab. Pressurization Cont Valve	7.0
Total Vapor Cycle ECS Weight	373.4

for the equivalent S-3A employing the air cycle ECS (Reference Table 2-48). This 262 pound reduction in weight is realized by virtue of the weight differences between the air cycle system ducting, valves, supports, etc. and the higher density vapor cycle package with its associated smaller and lighter Freon lines and valves.

For the current S-3A aircraft, which does not employ the 270 Vdc Power Supply technology, the total potential weight savings grows to 318 pounds for a reduction of 46 percent.

In summary, application of the 270 Vdc power supply technology to the S-3A in conjunction with utilization of a Freon vapor cycle ECS will not only offer considerable weight savings, but substantially higher avionic system reliability due to lower avionic component junction temperatures.

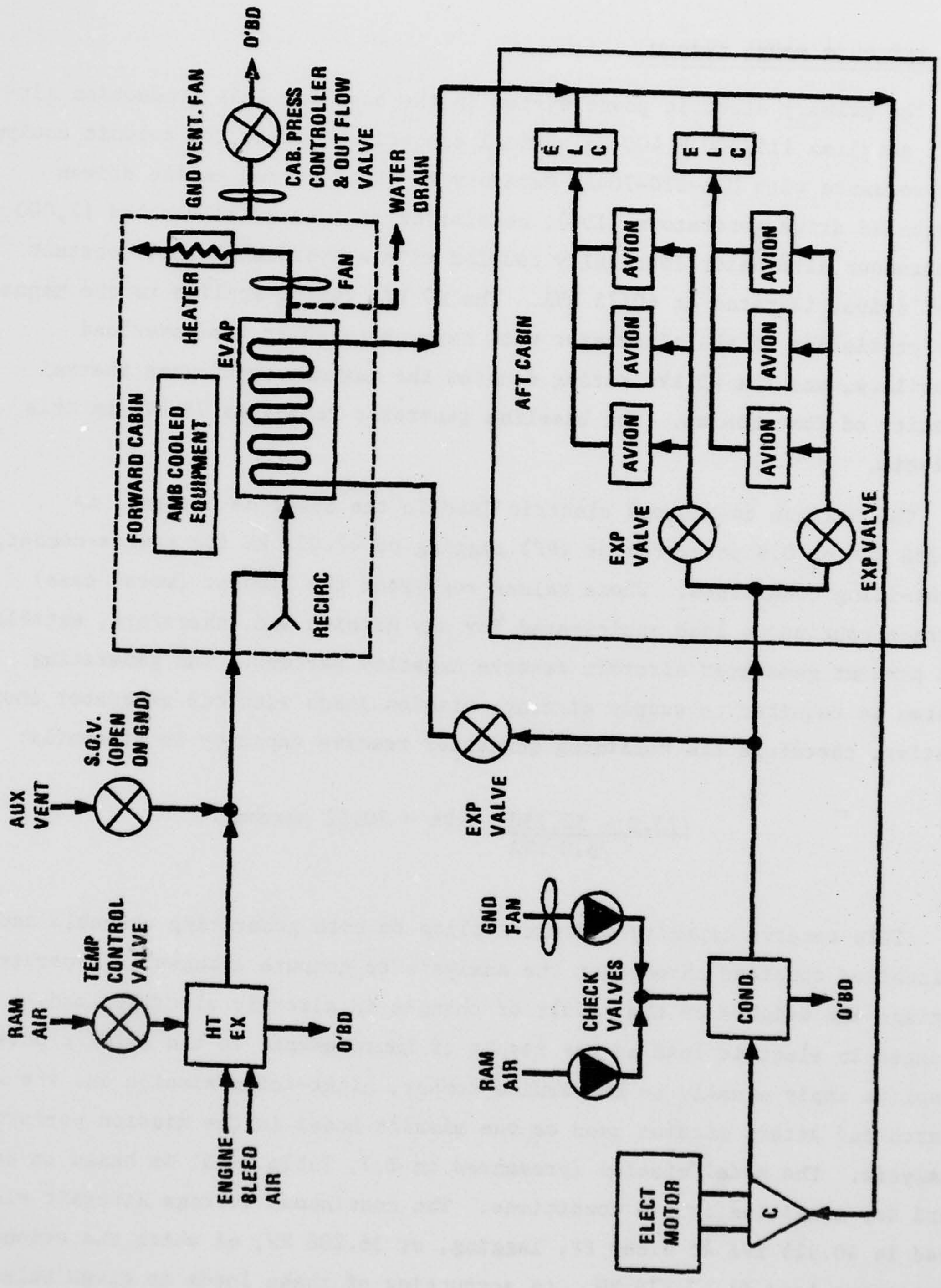


Figure 2-20. S-3A Vapor Cycle ECS

2.4 ELECTRIC POWER SYSTEM

The primary electric power system in the baseline S-3A production aircraft supplies 115/200 V 400 Hz nominal electric power to the avionic equipment in accordance with MIL-STD-704A, Category B. Each of two engine driven integrated drive generators (IDG), consisting of a spray oil-cooled 12,000 rpm synchronous alternator intregally coupled with a hydromechanical constant speed drive, is rated at 60/75 kVA. The 60 kVA rating applies to the magnetic characteristics of the alternator with respect to short time overload capability, and the 75 kVA rating denotes the maximum continuous thermal capacity of the machine. The baseline generator rating is 75 kVA in this analysis.

The maximum continuous electric load in the baseline aircraft is 52.258 kVA at 0.9 power factor (PF) lagging or 47.032 kW for cruise-combat, night-icing conditions. These values represent the highest (worst case) average continuous load anticipated for any mission and, therefore, establish the present generator aircraft reserve capacity percent. The generating system is required to supply aircraft mission loads with one generator inoperative, therefore the remaining generator reserve capacity is presently:

$$\frac{(75.0 - 52.258)\ \text{kVA}}{75.0\ \text{kVA}} = 30.32 \text{ percent}$$

This reserve capacity percent applies to both generating channels and is maintained constant throughout the analysis to compute changes in generator ratings and weights as the result of changes in aircraft electric load. Changes in electric load as the result of improvements in the avionic power supplies apply equally to the cruise-combat, night-icing mission and the ASW search and attack mission used as the mission model in the mission performance analysis. The model mission (presented in 2.7, Table 2-55) is based on standard day non-icing cruise conditions. The continuous average aircraft electric load is 40.913 kVA at 0.885 PF, lagging, or 36.208 kW, of which the avionics continuous load is 17.570 kW. An accounting of these loads is given below:

Avionics, 400 Hz continuous average	19.302 kVA
28 Vdc, 82.6 amperes continuous average (Converted by T/R 400 Hz input)	2.895 kVA
Heating, lighting, ventilation, continuous average	14.772 kVA
Flight controls, instruments, misc., continuous average	3.944 kVA
Total for aircraft	40.913 kVA
Total for aircraft (At 0.885 PF lagging)	36.208 kW
Avionics, 400 Hz continuous average (19.302 kVA at 0.885 PF)	17.082 kW
Avionics, 28 Vdc, 14.8 amperes continuous average (at 0.85 T/R conversion efficiency)	0.488 kW
Avionics total for aircraft - - -	17.570 kW

An avionic utilization factor of 0.656 for the model mission was derived from the ratio of the mission avionics average load, 17.570 kW, and avionic total connected load, 26.783, i.e. $\frac{17.570}{26.783} = 0.656$.

Total connected avionic load, expressed in units of power, is defined in this analysis as the sum of the loads of all individual equipments installed in the aircraft operating simultaneously in their maximum duty cycle modes. Mission average load, expressed in units of power, is the sum of the power consumption of each individual avionic equipment installed in the aircraft, operating or not during the mission, integrated over the time of the mission, e.g., watt hours divided by hours. Note that the avionic total connected load is the sum of the maximum duty cycle avionic's heat dissipation in Table 2-46, 25.651 kW, and the maximum duty cycle radio and radar emissions from the aircraft, 1.132 kW.

2.4.1 Electric Load Reduction - Optimized S-3A, Configuration 2

As the result of 270 Vdc power supply efficiency improvements the total maximum heat dissipation, tabulated in 2.3, was reduced from 25.651 kW in the

baseline S-3A to 20.867 kW in the optimized S-3A, Configuration 2 system, a reduction of 4.784 kW. Consequently, the connected load is reduced the same amount. Applying the 0.656 utilization factor discussed earlier, the average continuous electric load for the model mission is reduced 3.138 kW, and the average continuous cruise combat load becomes:

Baseline S-3A, cruise-combat	47.032 kW
Power supply improvements	3.138 kW
Aircraft total	43.894 kW

2.4.1.1 Generator Rating and Relative Weight Factor - Configuration 2

Because the remaining generating channel is required to supply the total aircraft load for mission completion with one generator inoperative, and in order to maintain the aircraft single generator percent reserve capacity equal to that of the baseline, the new generating channel rating becomes:

$$\frac{43.894}{47.032} \times 67.500 = 62.994 \text{ kW}$$

$$\frac{62.994 \text{ kW}}{0.90 \text{ PF}} = 69.993 \text{ kVA},$$

and the generating channel weight factor is:

$$\frac{43.894}{47.032} = 0.9333$$

In the detailed electric system weight analysis, the weight factor is taken to the next higher third significant digit.

Electric loads and generator ratings in this analysis are expressed in real power, i.e., watts, as are avionic loads, to facilitate direct comparison of the effects of 270 Vdc avionic power supply efficiency improvements. Generating channel ratings are also expressed in relative volt-amperes (kVA) for subjective comparison with 400 Hz system ratings.

2.4.2 Electric Load Increase - Optimized S-3A, Configuration 3

Conversely, in the optimized S-3A, Configuration 3, the average mission electric load increases as the result of changing the baseline aircraft ECS to

an electrically driven vapor cycle ECS. The average continuous cruise-combat electric load in this case becomes:

Baseline S-3A, cruise-combat		47.032 kW
Power supply improvements	−	3.138 kW
Added vapor cycle ECS	+	15.217 kW
Aircraft total		59.201 kW

2.4.2.1 Generator Rating and Relative Weight Factor - Configuration 3

Again, because either generating channel is required to supply the total aircraft load for mission completion, and in order to maintain the aircraft single generator percent reserve capacity constant, the new generator rating becomes:

$$\frac{59.201}{47.032} \times 67.500 = 84.965 \text{ kW}$$

$$\frac{84.965 \text{ kW}}{0.90 \text{ PF}} = 94.405 \text{ kVA}$$

and the generating channel weight factor is:

$$\frac{59.201 \text{ kW}}{47.032 \text{ kW}} = 1.2587$$

The weight factor is taken to the next higher third significant figure in the detailed weight analysis. Comments on electric loads and generating channel ratings in 2.4.1.1 apply.

2.4.3 Generating System Weight Reduction

Changes in generating subsystem weights, as the result of reduced electric load caused by changes in avionic power supply efficiencies, were computed by item numbers in accordance with the accounting format of AN-9102-C, Detail Weight Statement. The individual weight factors F and F2 applied to the electrical group items identified in Table 2-51 are shown in Tables 2-52 and 2-53.

TABLE 2-51. ELECTRIC POWER SYSTEM WEIGHT SUMMARY

Power System Components	Power System Component Weights - Lbs		
Element No. - Description	400 Hz Power Supplies - Air Cycle ECS Air Cold Plate Cooled - Baseline S-3A 75 KVA Generator Rating	270 Vdc Power Supplies - Air Cycle ECS Air Cold Plate Cooled - (Configuration 2) 70 KVA Generator Rating	270 Vdc Power Supplies - Vapor Cycle ECS Vapor Expansion Cold Plate Cooled (Configuration 3) 94 KVA Generator Rating
05 - Generators	178.8	166.9	225.1
07 - Gen Oil Cooling	34.2	31.9	43.1
08 - APU Generator	20.3	20.1	20.1
11 - Battery	1.5	1.5	1.5
12 - Battery Container	.5	.5	.5
17 - Transformer/Rect	24.3	23.2	23.2
22 - Transformers	6.5	6.5	6.5
23 - Power Diodes	3.2	3.2	3.2
25 - Generator Control	11.6	10.8	14.6
26 - Cutouts and Voltage Reg	2.4	2.3	2.3
28 - Switches, Rheostats	108.1	① 118.7	① 149.4
29 - Circuit Bkrs and Fuses	23.5	① 25.8	① 32.5
30 - Junct, Fuse, Dist Boxes	21.2	16.1	20.2
31 - Receptacles and Connectors	92.1	67.6	85.1
32 - Relays	43.0	② 42.0	② 52.9
33 - Wiring	122.5	93.0	117.0
34 - Conduit	10.6	9.8	9.8
35 - Ext Power System	4.6	4.3	5.8
37 - Lights, Interior	25.3	25.3	25.3
38 - Lights, Exterior	18.6	18.6	18.6
41 - Signal Devices, Lights	18.3	18.3	18.3
46 - Equip Supports, Wing	13.7	13.6	17.1
47 - Equip Supports, Tail	.6	.6	.6
48 - Equip Supports, Body	42.8	32.5	40.9
49 - Equip Supports, Nacelle	3.2	3.2	4.0
Total	831.4	756.3	937.6
Δ From Baseline S-3A	0	-75.1	+106.2

TABLE 2-52. ELECTRICAL GROUP WEIGHT - OPTIMIZED S-3A, CONFIGURATION 2.

ITEM	WT_P	F_1	F_2	WT_N	ΔWT
05	178.8	0.934		166.9	-11.9
07	34.2	0.934		31.9	- 2.3
08	20.3	0.990		20.1	- 0.2
11	1.5	1.00		1.5	0
12	0.5	1.00		0.5	0
17	24.3	0.956		23.2	- 1.1
22	6.5	1.0		6.5	0
23	3.2	0.999		3.2	0
25	11.6	0.934		10.8	- 0.8
26	2.4	0.956		2.3	- 0.1
28	108.1	0.734	① 1.496	118.7	+10.6
29	23.5	0.734	① 1.496	25.8	+ 2.3
30	21.2	0.759		16.1	- 5.1
31	92.1	0.734		67.6	-24.5
32	43.0	0.734	② 1.332	42.0	- 1.0
33	122.5	0.759		93.0	-29.5
34	10.6	0.925		9.8	- .8
35	4.6	0.934		4.3	- 0.3
37	25.3	1.00		25.3	0
38	18.6	1.00		18.6	0
41	18.3	1.00		18.3	0
46	13.7	0.990		13.6	- 0.1
47	0.6	0.970		0.6	0
48	42.8	0.759		32.5	-10.3
49	3.2	1.00		3.2	0
Total	831.4			756.3	-75.1

① Weight Factor in System. Weight Factor of Individual 270 Vdc Device = 2.9

② Weight Factor in System. Weight Factor of Individual 270 Vdc Device = 1.8

TABLE 2-53. ELECTRICAL GROUP WEIGHT - OPTIMIZED S-3A, CONFIGURATION 3.

Item	WT_P	F_1	F_2	WT_N	ΔWT
05	178.8	1.259		225.1	+46.3
07	34.2	1.259		43.1	+ 8.9
08	20.3	0.990		20.1	- 0.2
11	1.5	1.000		1.5	0
12	0.5	1.000		0.5	0
17	24.3	0.956		23.2	- 1.1
22	6.5	1.000		6.5	0
23	3.2	0.999		3.2	0
25	11.6	1.259		14.6	+ 3.0
26	2.4	0.956		2.3	- 0.1
28	108.1	0.9239	① 1.496	149.4	+41.3
29	23.5	0.9239	① 1.496	32.5	+ 9.0
30	21.2	0.955		20.2	- 1.0
31	92.1	0.9239		85.1	- 7.0
32	43.0	0.9239	② 1.332	52.9	+ 9.9
33	122.5	0.955		117.0	- 5.5
34	10.6	0.925		9.8	- 0.8
35	4.6	1.259		5.8	+ 1.2
37	25.3	1.000		25.3	0
38	18.6	1.000		18.6	0
41	18.3	1.000		18.3	0
46	13.7	1.246		17.1	+ 3.4
47	0.6	0.970		0.6	0
48	42.8	0.955		40.9	- 1.9
49	3.2	1.259		4.0	+ 0.8
Total	831.4			937.6	+106.2

① Weight Factor in System. Weight Factor of Individual 270 Vdc Device = 2.9

② Weight Factor in System. Weight Factor of Individual 270 V Device = 1.8

The derivation of weight factor F_1 for each electric system item was based on the theoretical conversion of only those present S-3A electric system elements or fractions of elements directly associated with the conversion of the avionics system power supplies from a 400 Hz input to a 270 Vdc input. A two-wire return 270 Vdc power distribution configuration was used. Wire, connector, circuit breaker, fuse, switch, relay, and equipment support weights were factored on the basis of the real component of ac power, i.e., watts, number of conductors, avionics connected load, and its percentage of total aircraft load. The balance of weight factors F reflect the secondary effects of 270 Vdc avionic conversion.

Weight factors F_2 reflect the impact of the use of functionally equivalent 270 Vdc devices in lieu of 400 Hz devices to the extent these devices are now used in the avionic power distribution system, and reflect the ratio of avionic power to the total aircraft electric load. In this analysis, the combined weight of 270 Vdc semiconductor switches and circuit breakers were considered to be 2.9 times that of standard 400 Hz mechanical devices. Similarly, the weight of a semiconductor relay was considered to be 1.8 times that of a standard mechanical relay.

2.5 ENGINE PERFORMANCE

The installed performance of the G.E. TF34-GE-400 turbofan engine used in this analysis was determined using G.E. digital computer deck no. 720071. All losses associated with the engine installation are accounted for in the engine performance computer program. These include internal losses (inlet total pressure loss), electric and hydraulic power extraction, fan bleed, compressor bleed, oil cooler drags and external drags (spillage), fan cowl friction, fan cowl boattail, core cowl scrubbing, core cowl boattail, pylon boattail, cooling air thrust, leakage and surface imperfection.

Actual engine characteristics measured in Lockheed flights tests were compared with the engine characteristics predicted by the status deck, i.e., engine deck no 720071. The actual measured engine fuel flows, at given thrust levels, were approximately 3 percent higher than status deck

predictions. Accordingly, a 1.033 multiplier was applied to status deck engine fuel flows used in this analysis. The adjusted status deck is identified as engine 82 and is also used to produce average engine S-3A Flight Handbook data.

Improved avionic system efficiency reduces electric power and environmental control system cooling loads. This affects engine performance by reducing the accessory gearbox power extraction required to drive the generators and by reducing the quantity of engine compressor bleed air required for environmental control system operation. In this analysis, the engine performance effects associated with the improved avionic power supplies reflect a 9.5 percent reduction in generator load and an 11.8 percent reduction in high flow environmental control system airflow.

Generator load is a direct input to the engine performance computer program. The environmental control system is modeled by a subroutine which operates in conjunction with the engine computer deck to balance engine bleed pressures and temperatures, bleed duct loss characteristics, ECS flow control valve characteristics, and cabin conditions to compute the engine bleed flowrate at a given flight condition. Engine deck identified as engine 417 reflects improved engine performance resulting from reduced bleed and power extraction. Figure 2-21 compares the baseline S-3A engine 82 performance and the improved avionic system engine (417) performance at 40,000 feet altitude and 0.6 Mach. At 1100 pounds thrust the improved avionic system results in an improvement in SFC of approximately 0.6 percent. The effects are similar at other operating conditions above 4000 feet altitude and where the ECS operates on high flow.

2.6 WEIGHT GROWTH FACTOR

During the preliminary design of a new aircraft, the configuration is variable. Under the assumption of a constant performance objective, an equation relating aircraft gross weight to the sum of the component weights can be written:

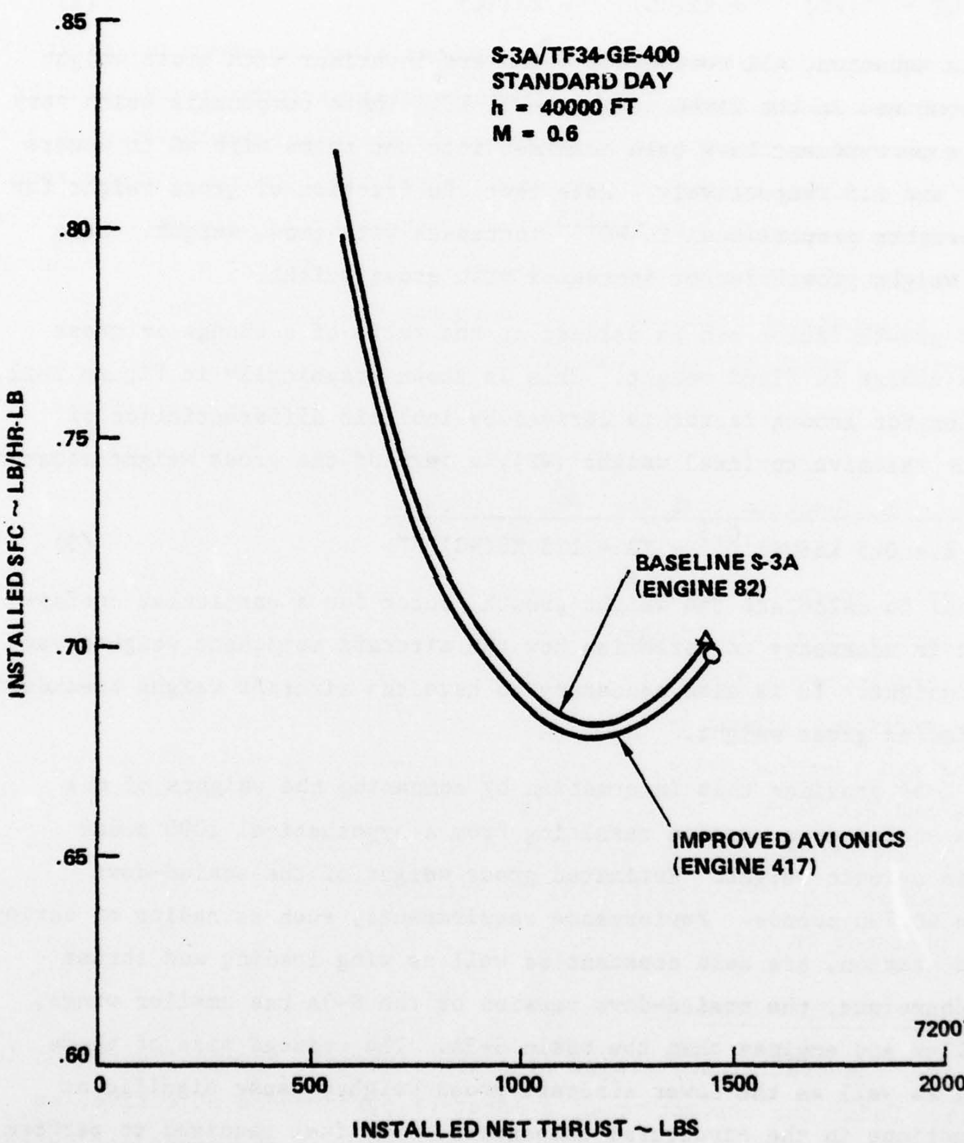


Figure 2-21. Effect of Improved Avionics on SFC

$$WG = WF + W1 + W2 + W3 \tag{1}$$

or as a function of WG:

$$WG = WF + K1(WG)^{0.5} + K2(WG)^{1.0} + K3(WG)^{1.5} \tag{2}$$

In this equation, all components which are invariant with gross weight have been combined in the fixed weight term, WF. Those components which vary with WG to some exponent have been combined into the terms with WG to powers of 0.5, 1.0 and 1.5 respectively. Note that the fraction of gross weight for component weights proportional to $WG^{1.5}$ increases with gross weight. This is why the weight growth factor increases with gross weight.

Weight growth factor can be defined as the ratio of a change in gross weight to a change in fixed weight. This is shown graphically in Figure 2-22. An expression for growth factor is derived by implicit differentiation of gross weight relative to fixed weight (WF), a term of the gross weight equation:

$$\frac{dWG}{dWF} = \frac{1}{1 - 0.5\ K1(WG)^{-0.5} - K2 - 1.5\ K3(WG)^{0.5}} \tag{3}$$

In order to calculate the weight growth factor for a particular configuration, it is necessary to establish how the aircraft component weights vary with gross weight. It is also necessary to have the aircraft weight breakdown for a particular gross weight.

Table 2-54 provides this information by comparing the weights of the S-3A with a scaled-down version resulting from a hypothetical 1000 pound reduction in avionic weight. Estimated gross weight of the scaled-down aircraft is 40,700 pounds. Performance requirements, such as radius of action and time on station, are held constant as well as wing loading and thrust loading. Therefore, the scaled-down version of the S-3A has smaller wings, tail, nacelles and engines than the basic S-3A. The reduced size of these components, as well as the lower aircraft gross weight, cause significant weight reductions in the structural components. The fuel required to perform the same mission is reduced in direct proportion to the gross weight.

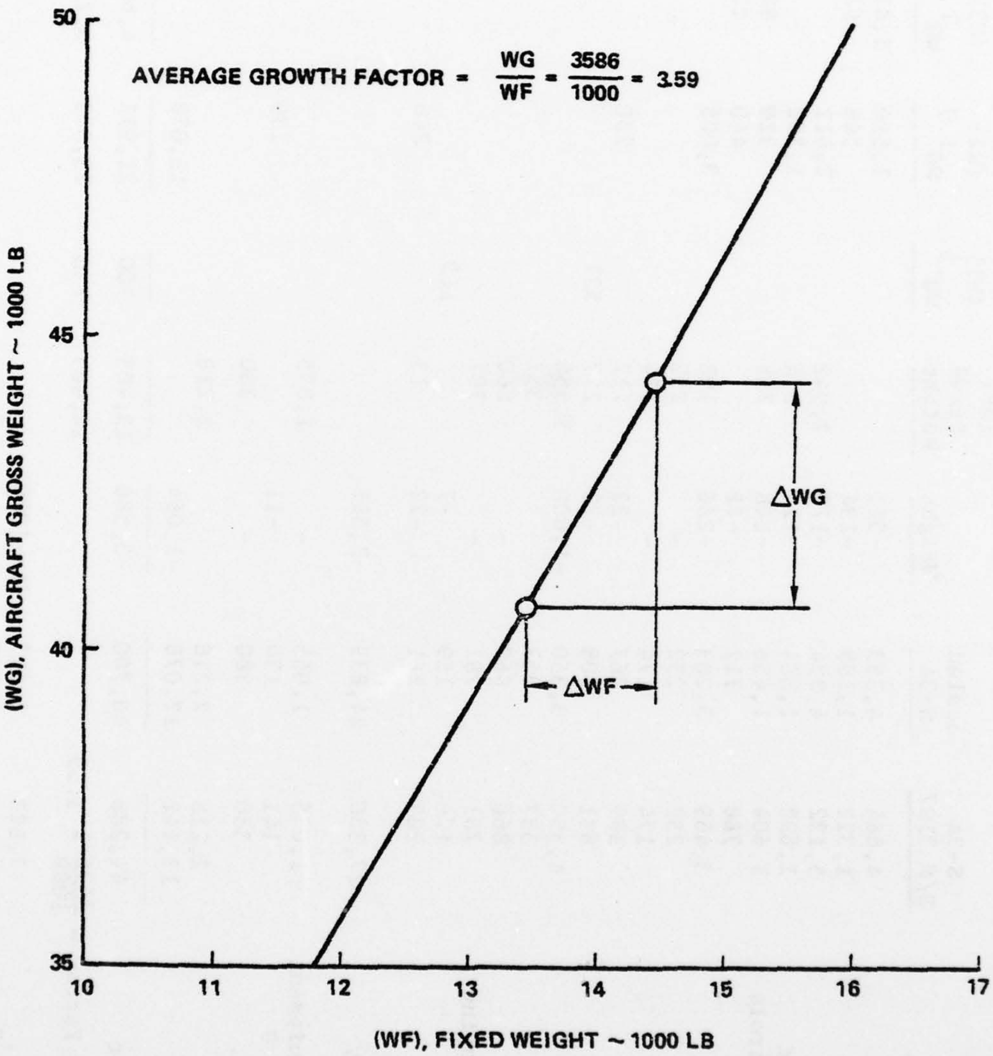


Figure 2-22. Weight Growth Factor for Constant Performance

TABLE 2-54. WEIGHT COMPARISON (LB)

Item	S-3A S/N 3107	Scaled S-3A	Weight	(WF) Fixed Weight	(W1) $WG^{.5}$	(W2) $WG^{1.0}$	(W3) $WG^{1.5}$	(WG) Total Weight
Wing	4,884	4,363	-521			1,510	2,853	
Tail	1,322	1,188	-134			568	620	
Body	5,132	4,954	-178	2,942		2,012		
Landing Gear	1,698	1,584	-114	234		1,350		
Surface Controls	1,604	1,456	-148	255		320	881	
Nacelles	788	712	-76			440	272	
Propulsion	3,469	3,203	-266	198		3,005		
APU	252	252	-	252				
Instruments	174	174	-	174				
Hydraulics	389	367	-22	117		250		
Electrical	831	808	-23	277	531			
Avionics	4,350	3,350	-1,000	3,350				
Armament	357	357		357				
Furnishings	860	860	-	860				
Air Conditioning	781	781	-	781				
Anti-Ice	176	169	-7		169			
Aux. Gear	283	261	-22	13		248		
Weight Empty	27,350	24,839	-2,511					
Crew & Equipment	1,055	1,055	-	1,055				
Unus. F & O	141	130	-11			130		
Fixed Arm.	380	380	-	380				
Ordnance	2,218	2,218		2,218				
Fuel	13,142	12,078	-1,064			12,078		
Gross Weight	44,286	40,700	-3,586	13,463	700	21,911	4,626	40,700
Ave. Growth Factor = $\frac{3536}{1000}$ = 3.59				14,463	730	23,839	5,254	44,286
Payload, lb.	7,623	6,623	(Δ=-1000)					
Wing Area, 4^2	598	547						
Thrust, lb.	18,550	17,043						

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ANALYSIS OF THE IMPACT OF A 270 VDC POWER SOURCE ON THE AVIONIC--ETC(U)
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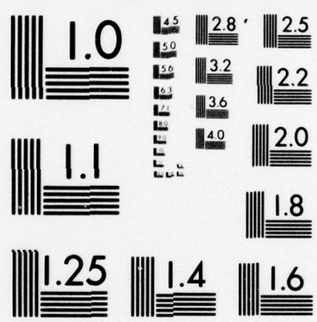

MICROCOPY RESOLUTION TEST CHART
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The total reduction in gross weight (ΔWG) of 3586 pounds divided by the initial 1000 pound reduction in avionic weight (ΔWF), yields an average growth factor of 3.59. As mentioned before, this growth factor varies with gross weight and is applicable only to the range of weights considered in Table 2-54.

From Table 2-54, a general expression for gross weight can be derived by determining the variation of each component with gross weight for the scaled-down S-3A (WG = 40,700 pounds). Total fixed weight which does not vary with changes in gross weight is 13,463 pounds. The remaining three terms of the gross weight equation are calculated here:

$$W1 = 700 = K1(WG)^{0.5} \qquad K1 = 700/WG^{0.5} = 3.470$$

$$W2 = 21{,}911 = K2(WG)^{1.0} \qquad K2 = 21{,}911/WG^{1.0} = 0.5383$$

$$W3 = 4626 = K3(WG)^{1.5} \qquad K3 = 4626/WG^{1.5} = 0.000563$$

Substituting into equation (3) for growth factor:

$$\frac{dWG}{dWF} = \frac{1}{1-0.5\ (3.470)(WG)^{-0.5} - 0.5383 - 1.5\ (0.000563)(WG)^{0.5}}$$

Solving for growth factor at a gross weight of 40,700 pounds:

$$\frac{dWG}{dWF} = \frac{1}{1 - 0.5\ (3.470)(0.00496) - .5383 - 1.5\ (.000563)(201.7)} = 3.54$$

At a gross weight of 44,286 pounds and with 1000 pounds added to avionics (WF = 13468 + 1000 = 14468), the growth factor becomes:

$$\frac{dWG}{dWF} = \frac{1}{1 - 0.5(3.47)(.00475) - .5383 - 1.5\ (.000563)(210.4)} = 3.63$$

The average weight growth factor is approximately midway between the two growth factors calculated above and plotted in Figure 2-23. For a more detailed explanation of growth factor, refer to Society of Allied Weight engineer's paper number 952, "The Growth Factor Concept," by Ben Saelman, May 1973.

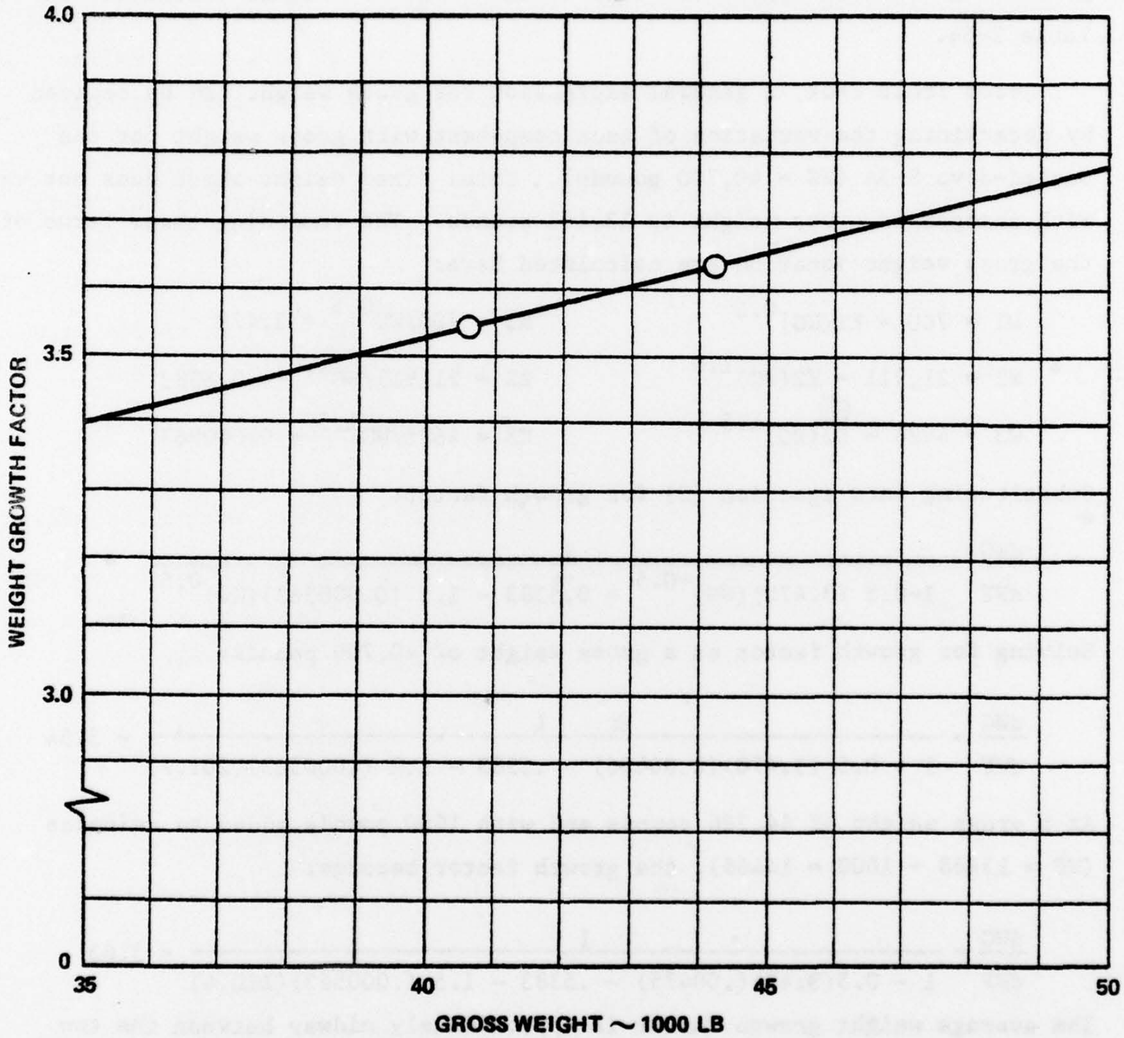


Figure 2-23. Weight Growth Factor Versus Gross Weight

2.7 MISSION PERFORMANCE ANALYSIS

This study was conducted to assess the impact of reduced avionic power supply weight, power dissipation, and size on the S-3A aircraft and its ASW mission. As previously shown, had the 270 Vdc primary aircraft power system been incorporated into the initial S-3A design, it would have been smaller and lighter consistent with certain geometric constraints such as weapons bay, cockpit quarters, etc., which must remain constant.

The aerodynamic performance criteria of principal interest is the basic search-and-attack mission, which involves cruise segments out to station and back and a loiter segment on station, see Table 2-55. The baseline S-3A can loiter for 4.5 hours at a speed of 370 knots and at a radius of 356 miles from home base. It carries a normal complement of stores and sonobuoys.

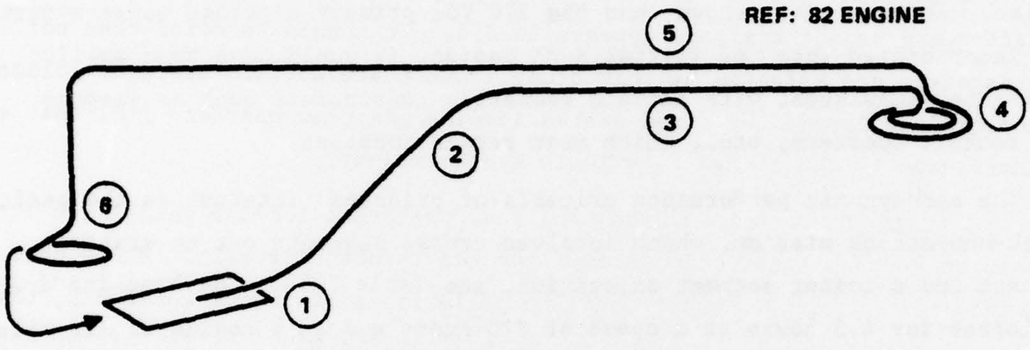
Computer programs were used to determine mission performance for the changes in weight, drag, engine characteristics, etc. The data used in the program reflected flight results including aircraft drag and engine fuel flows.

The baseline aircraft is the S-3A Viking with a high wing, swept 15 degrees aft. A TF-34 fan engine is mounted beneath each wing. The engines have a high bypass ratio of 6 and give good cruise specifics. Aircraft weight to perform the ASW mission is 44,286 pounds.

The baseline S-3A performance was first determined for the search-and-attack mission. Next, the separate effects of changing avionic payload and power/cooling requirements on mission time-on-station (TOS) and radius was assessed for a 500 pound reduction in aircraft payload; aircraft size did not change. Engine fuel flow was reduced reflecting the power/cooling reductions.

The aircraft growth factor, wing loading, and thrust loading guidelines were developed for a reduction in the avionic package. This was used to determine gross takeoff weight for reduced aircraft size. Wing loading and thrust loading scale factors were used to scale down the wing and engine size for the smaller aircraft.

TABLE 2-55. BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D"
(SPECIFICATION AIRCRAFT)



Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-up & Takeoff	44,286	-	0	0.08	460	-
2. Climb	43,826	220	0	0.32	1149	99
3. Cruise Out at Optimum Altitude	42,677	355	36,100	0.73	1292	257
4. Loiter on Station	41,388	370	38,000 to 40,000	4.5	7624	0
5. Cruise Back at Optimum Altitude	33,760	356	40,000	1.02	1464	356
6. Reserve Loiter	32,296	160	0	0.33	496	-
5% Initial Fuel Reserve	31,800	-	-	-	657	-

Totals:	Mission Time (Items 2 through 5)	6.57 Hr
	Mission Fuel (Items 1 through 5)	11,989 Lb
	Fuel Load	13,142 Lb
	Radius of Operation	356 NM

Reducing the avionic package affects other aircraft systems, because of the interdependence of one system upon another, such as cooling, electrical, hydraulic, structural, fuel, etc. All of these factors or systems are part of the airplane growth factor. A more complete description of the growth factor and weight analysis appears in 2.6. It should be noted that not all subsystems are affected by this study. There are certain space or volume constraints imposed by fixed stores loading and crew quarters etc. that are unaffected by the change in avionic system weight.

The growth factor and the wing loading/thrust loading guidelines were used to keep performance constant, for the reduced aircraft. While these guidelines are not an exact means of achieving performance constants, they are satisfactory for the size and scope of this study. Review of the data presented will reveal that a reduction of 500 pounds in the avionic payload will result in an aircraft whose GTOW is 42,486 pounds; a 1800 pound reduction from the S-3A GTOW of 44,286 pounds.

2.7.1 Aircraft Description

The aircraft selected for the study was a standard Navy S-3A Viking from Lot VII, Serial No. 3147 and store loading "D". When rigged to perform the mission described above, it weighs 44,286 pounds. The ordinance includes both depth bombs and sonobuoys which are all carried internally. It's assumed that the ordinance may not be totally expended throughout the mission and could be returned with the aircraft at landing. The baseline aircraft wing is a modified supercritical wing and has a planform area of 598 square feet. The aircraft carries 13,142 pounds of fuel, all internally.

In those cases where airplane size is changed, aircraft shape and arrangement remained essentially the same. Therefore, aircraft aerodynamic parameters, such as lift, drag, and pitching moment coefficients were kept the same although the forces and moments varied. Thrust-to-weight ratios and wing loading were maintained at the same values as those required for the baseline S-3A configured to perform the standard mission (4.5 hours at 356 nautical miles).

Volume changes to the aircraft were quite small, particularly to the wing and empennage, even though moderate changes to their platform areas did occur. Fuselage volume changes were limited also because of size constraints for fixed systems such as weapons, crew quarters, etc. For the weight, area, and volume changes contemplated here (0 to 1000 pounds Δ avionic payload) these are reasonable assumptions.

The engine definition for the computer programs used for the baseline aircraft is that used at Lockheed for the basic S-3A, identified as the 82 engine in this report, which has been previously tested and confirmed. The engine mathematical model was modified, for those portions of the study which are characterized by avionic cooling and power extraction reductions, to reflect the reduction in fuel flow rate and reidentified as the 417 engine.

The basic mission used for the analysis was maintained as a constant and corresponded to a specification search-and-attack mission for which the S-3A was originally designed. The mission consisted of the following segments:

- Warmup and takeoff
- Climb to cruise altitude (on course)
- Cruise out to search area
- Search on station (370 knots airspeed at 38,000 to 40,000 feet altitude
- Cruise back to the ship
- Reserves:

  5 percent total fuel

  Loiter 20 minutes.

The takeoff consists of a block of fuel defined as that required by the engines running at normal rated power for 5 minutes at sea level static conditions. The climb-to-cruise altitude is done at intermediate power and at optimum climb speed which is close to minimum time. Cruise altitude is determined by optimum cruise conditions which reflect speed, fuel flow, weight, and configuration. The altitude and speed for cruise were selected

to give the maximum range for the amount of fuel used. The search portion consisted of a 4.5 hour loiter at 370 knots at a part-power setting. It was flown at 38,000 to 40,000 feet and at the maximum range point. Reserves consisted of a fixed percentage (5 percent) of the total fuel onboard and of a variable part which allows a 20 minute loiter at sea level at partial power. Optimum speeds are selected for minimum fuel flow.

The baseline mission performance for the S-3A permitted a loiter of 4.5 hours on station at a radius of 356 nautical miles. This performance requirement was applied to all the aircraft configurations analyzed as the basis for comparison, and the weights, fuel quantities, areas, etc., were adjusted to meet this objective. A detailed breakdown of the mission segments and pertinent performance data regarding these segments is presented in Table 2-55. It shows weight, speed, altitude, time, fuel and distance.

2.7.2 Effects of Avionics Improvements on Basic S-3A

This portion of the study identifies mission performance improvements obtainable with the basic S-3A resulting from improvements in the avionic package but with no change in the basic airframe. The improvements in the avionic package include a reduction in weight, size, power requirements, and cooling requirements. This in turn means a reduction in S-3A weight and a corresponding increase in TOS or in mission radius. Reducing weight reduces airplane drag and, therefore, the engine power and fuel flow required to perform the mission. Reduction in the power and cooling requirements also reduces fuel requirements for the mission. Figure 2-24 shows the trade-off in TOS and mission radius for 500/1000 pound reductions in aircraft gross weight. As the figure shows, all of these aircraft with their improved avionics and reduced weight can achieve a better mission radius than the reference baseline S-3A. Figures 2-25 and 2-26 are crossplots of Figure 2-24 showing more readily the impact of weight change on mission radius or TOS. The data is shown for both the baseline S-3A (82) engine and S-3A (417) engine with the improved avionics. As noted from the curves, the gains for this weight range are modest; 14 nautical mile range extention holding

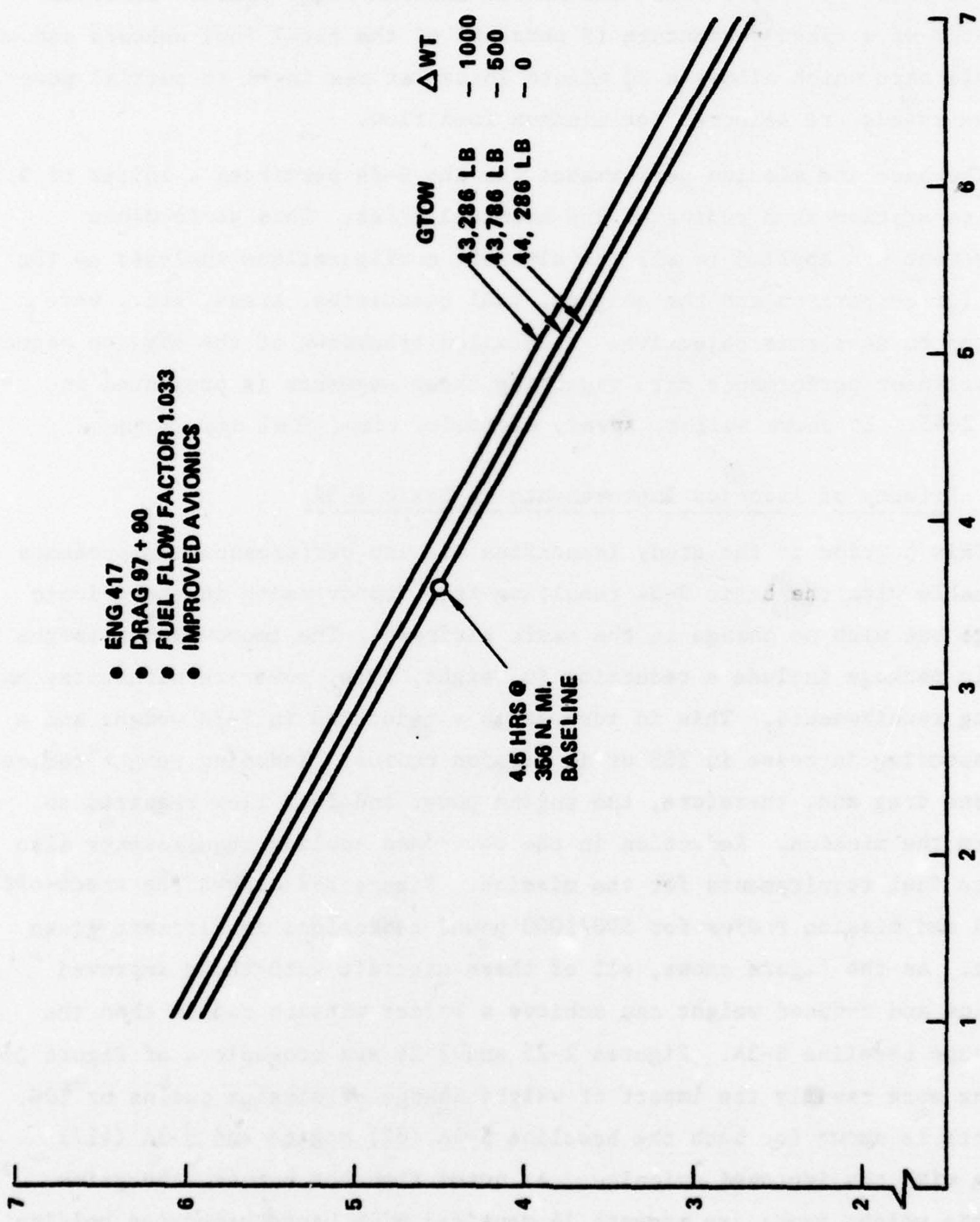


Figure 2-24. Effect of Weight on Mission Performance
Search and Attack Mission

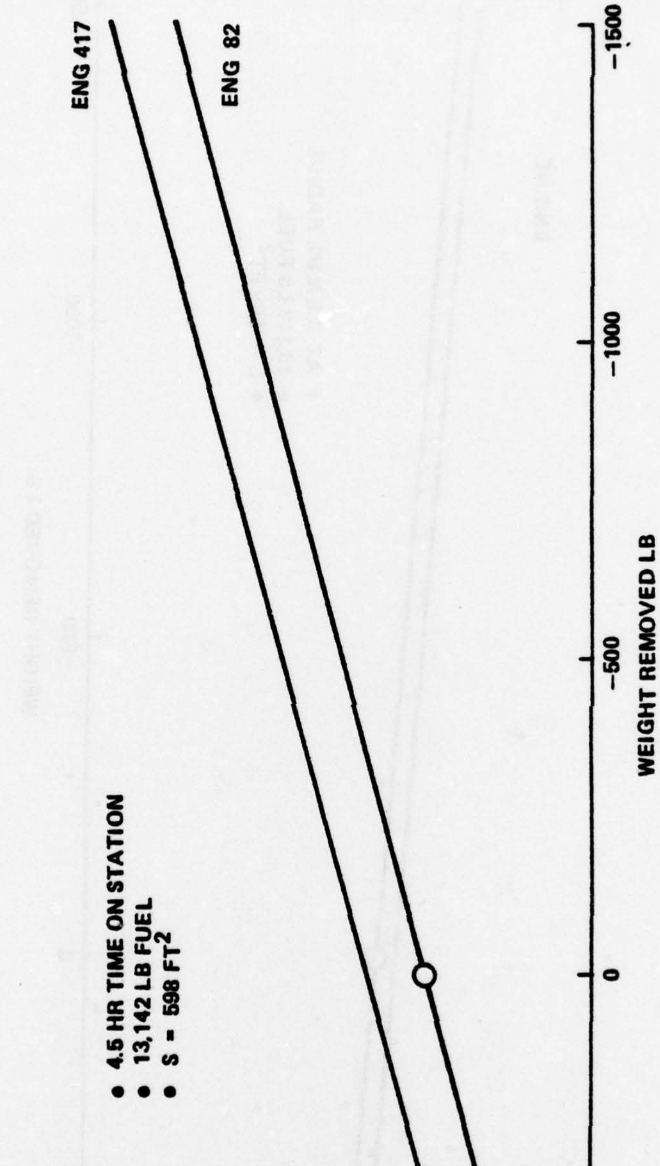


Figure 2-25. Impact of Improved Avionics on Mission Performance (Constant Time On Station)

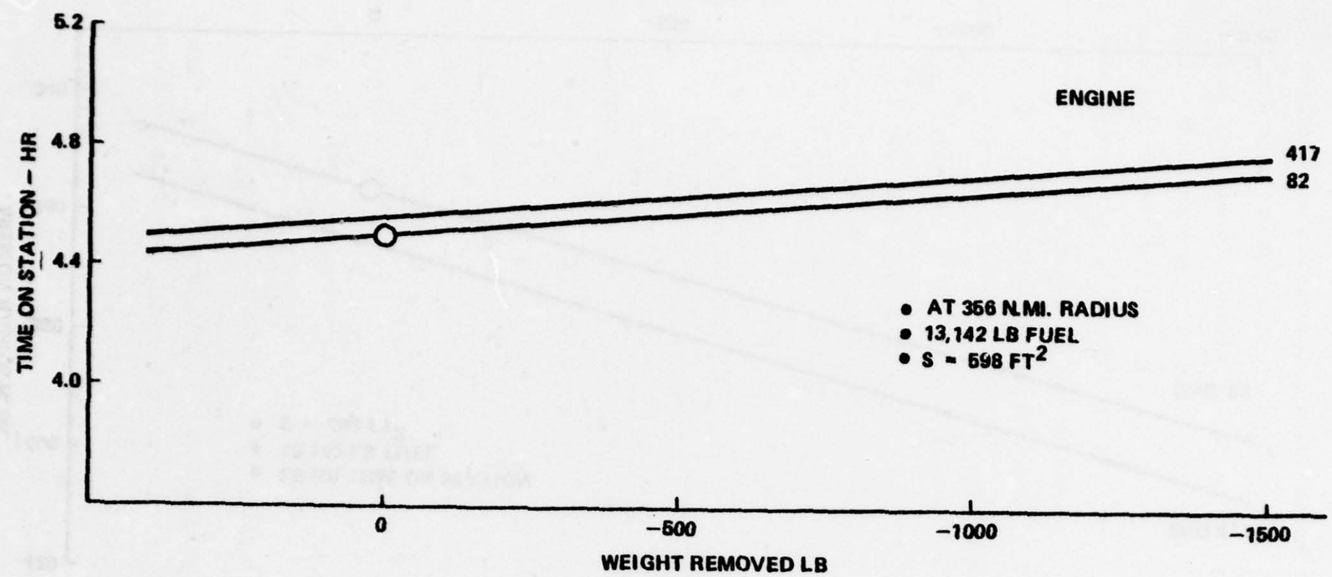


Figure 2-26. Impact of Reduced Avionics Weight on Mission Performance (Constant Mission Radius)

TOS constant or 5 minutes TOS mission radius constant for a 500 pound weight reduction. Table 2-56 presents mission segment data for aircraft which have the same mission radius as the baseline (356 nautical miles), but with varying TOS. The table is given for a 500 pound reduction in aircraft weight and includes utilization of the 417 engines. For these aircraft the radius is held constant and the TOS is allowed to increase as aircraft gross weight is reduced. For 500 pounds of weight removed, the loiter time is increased 8 minutes. Table 2-57 presents similar data, but the TOS is held constant, and the mission radius is allowed to increase as weight is reduced. The radius increases to 375 nautical miles for a 500 pound weight reduction.

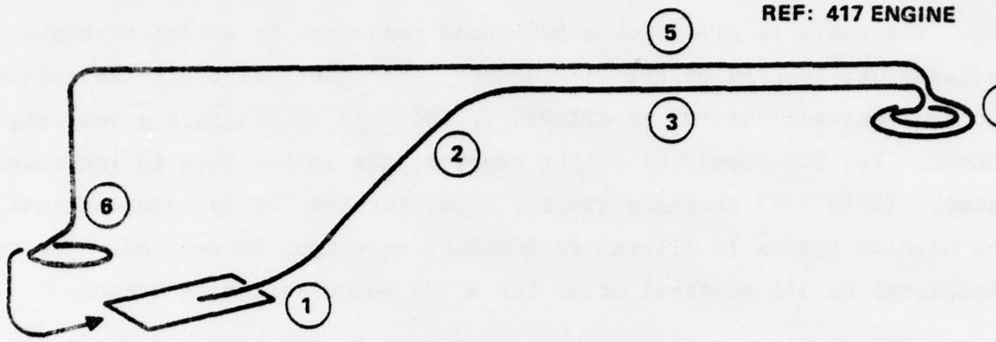
Up to this point, no changes have been made to the basic aircraft, such as wing, fuselage, and empennage. Therefore, the aircraft growth factor has not been affected. Accounting for this, results in more significant changes in aerodynamic performance.

2.7.3 Reduced S-3A Size

Recognition of the aircraft's growth factor for a given-pound reduction in payload early in the design phase results in a significantly smaller and lighter aircraft to perform the same mission functions. This comes about because of a fallout effect in aircraft size for a given change to the aircraft. That is, reduction in weight of one system permits a corresponding reduction in size of several others, but not all aircraft systems, such as controls, landing gear, hydraulic systems, etc. This cascade effect is called the growth factor. For the S-3A, this factor, which results from the changes in size, volume, power, and cooling requirements of the avionics package, amounts to 3.6 lb/lb. This means that a 1-pound reduction in avionic weight and size results in a 3.6-pound reduction in aircraft gross weight.

In order to maintain aerodynamic performance of the aircraft consistent with the baseline S-3A, certain scaling factors were held constant. These include the wing loading and thrust loading. For the weight range covered in this study the fuel faction remains very nearly constant, although it was not constrained to do so. The performance items that are intended to be held

TABLE 2-56. S-3A ASW SEARCH AND ATTACK MISSION, LOADING "D"
(VARIANT A -500 LBS PAYLOAD)

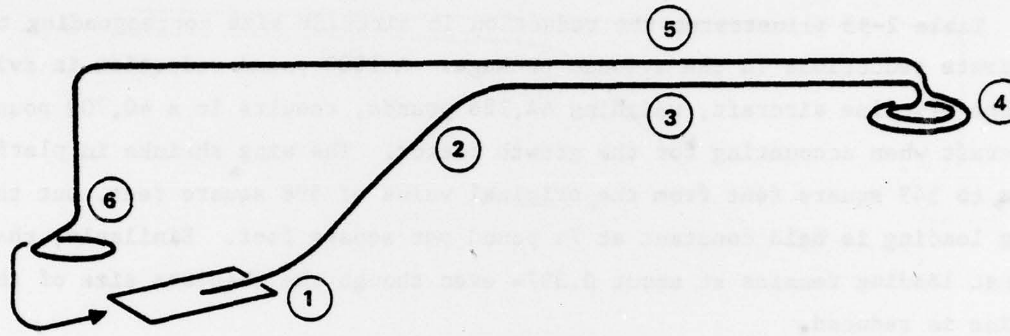


Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-up & Takeoff	43,786	-	0	0.08	460	-
2. Climb	43,326	220.3	0	0.32	1090	97
3. Cruise Out at Optimum Altitude	42,236	355.2	36,500	0.78	1300	259
4. Loiter on Station	40,936	370	38,000	4.58	7689	0
5. Cruise Back at Optimum Altitude	33,247	355	40,000	1.00	1490	356
6. Reserve Loiter	31,757	158.4	0	0.33	456	-
5% Initial Fuel Reserve	-	-	-	-	657	-

Totals: Mission Time (Items 2 through 5)	6.70 Hr
Mission Fuel (Items 1 through 5)	12,029 Lb
Fuel Load	13,142 Lb
Radius of Operation	356 NM

TABLE 2-57. S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D"
(VARIANT B -500 LBS PAYLOAD)

REF: 417 ENGINE



Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-up & Takeoff	43,786	-	0	0.08	460	-
2. Climb	43,326	220	0	0.37	1135	98
3. Cruise Out at Optimum Altitude	42,191	355	36,500	0.78	1372	277
4. Loiter on Station	40,819	370	38,000	4.5	7510	0
5. Cruise Back at Optimum Altitude	33,309	355	40,000	1.09	1518	375
6. Reserve Loiter	31,791	158	0	0.33	490	-
5% Initial Fuel Reserve	-	-	-	-	657	-

Totals:	Mission Time (Items 2 through 5)	6.69 Hr
	Mission Fuel (Items 1 through 5)	11,995 Lb
	Fuel Load	13,142 Lb
	Radius of Operation	375 NM

constant, beside mission performance, include takeoff distance, acceleration, cruise performance, cruise altitude and speed, stall-speed, turn performance, and numerous others.

Table 2-58 illustrates the reduction in aircraft size corresponding to discrete reductions in the avionic package. A 1000-pound reduction in avionics of the baseline aircraft, weighing 44,286 pounds, results in a 40,700 pound aircraft when accounting for the growth factor. The wing shrinks in platform area to 549 square feet from the original value of 598 square feet, but the wing loading is held constant at 74 pound per square foot. Similarly, the thrust loading remains at about 0.3974 even though the absolute size of the engine is reduced.

Figure 2-27 presents the variation of the aircraft weight as a function of the avionic payload change. The slope of the curve of delta weight change gives the aircraft growth factor. Aircraft size (GTOW) for weight reductions other than 500 pounds can be read graphically from the figure. Figure 2-28 shows additional aircraft size parameters including zero fuel weight and fuel fractions. Figure 2-29 shows the specific solution point of the study for a 500-pound reduction in the avionic package. The required mission range of 356 nautical miles is selected so the corresponding gross take-off weight and wing area can be read from this figure. Table 2-59 shows mission segment details for an aircraft with a 500-pound reduction in avionic payload and incorporating the growth factor.

2.7.4 Application of 270 Vdc Power System to Mission Performance

As the basis for quantifying the effects of the 270 Vdc primary aircraft power described in previous sections of this report, mission aerodynamic performance analyses were conducted on three theoretical S-3A aircraft configurations and related to a basic baseline S-3A as the model vehicle. Those parameters analyzed were GTOW, radius of operation, TOS and fuel usage. The data derived is shown in Tables 2-60 through 2-63.

TABLE 2-58. REDUCTION IN AIRCRAFT SIZE FOR REDUCED AVIONICS WEIGHT

Aircraft	GTOW lb	Fuel lb	S ft^2	T lb
Baseline	44,286	13,142	598	17,600
-500 lb	42,486	12,600	574	16,884
-1000 lb	40,700	12,014	549	16,174

- 1.033 Fuel Factor
- Fuel Fraction 0.296
- W/S 74.05 PSF
- T/W 0.3974
- Growth Fictor = 3.6

The basic mission used for the analysis was maintained as a constant and corresponded to a specification search-and-attack mission, as defined on page 2-162, for which the S-3A was originally designed.

The aircraft selected as the model vehicle is a Production Lot VII S-3A, Serial No. 3147 (Navy Serial No. 160657). It is identified as Baseline S-3A, ASW Search & Attack Mission, Loading "D." The pertinent weight and performance data assembled for this aircraft is summarized below:

Gross Weight	44,286 pounds
Weight empty	27,350 pounds
Useful load	16,936 pounds
Total fuel	13,253 pounds
Useable fuel	13,142 pounds
Avionics payload	3,322 pounds
Stores payload	2 598 pounds

The aircraft ordnance includes 2 depth bombs (B-57) and 48 sonobuoys which are all carried internally. It is assumed that the ordnance is not expended throughout the mission and is returned in total with the aircraft at landing. Although this is somewhat conservative, it is conceivable and considered applicable for purposes of calculating mission performance and aircraft sizing.

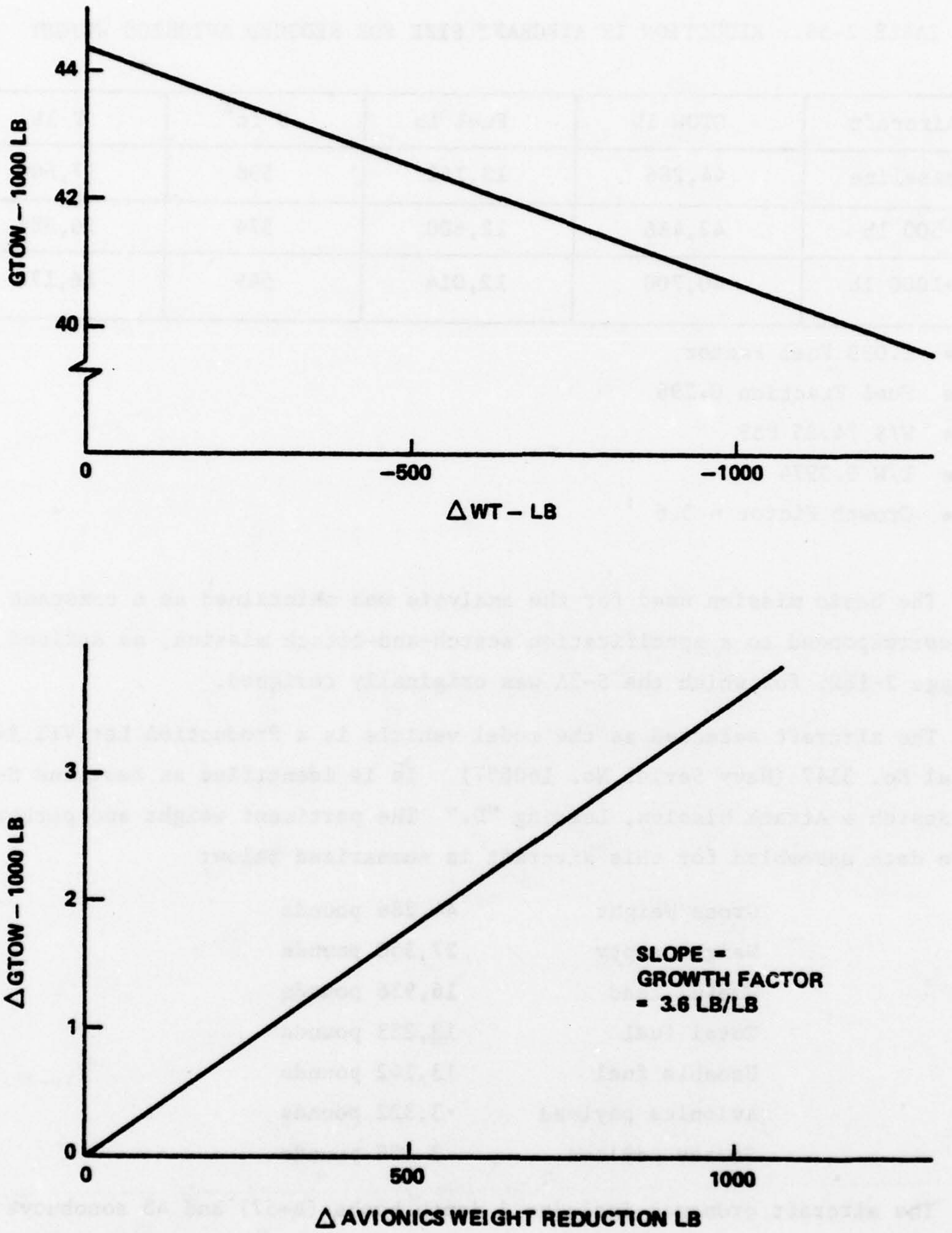


Figure 2-27. Effect of Avionics System Weight Reduction on S-3A Gross Weight

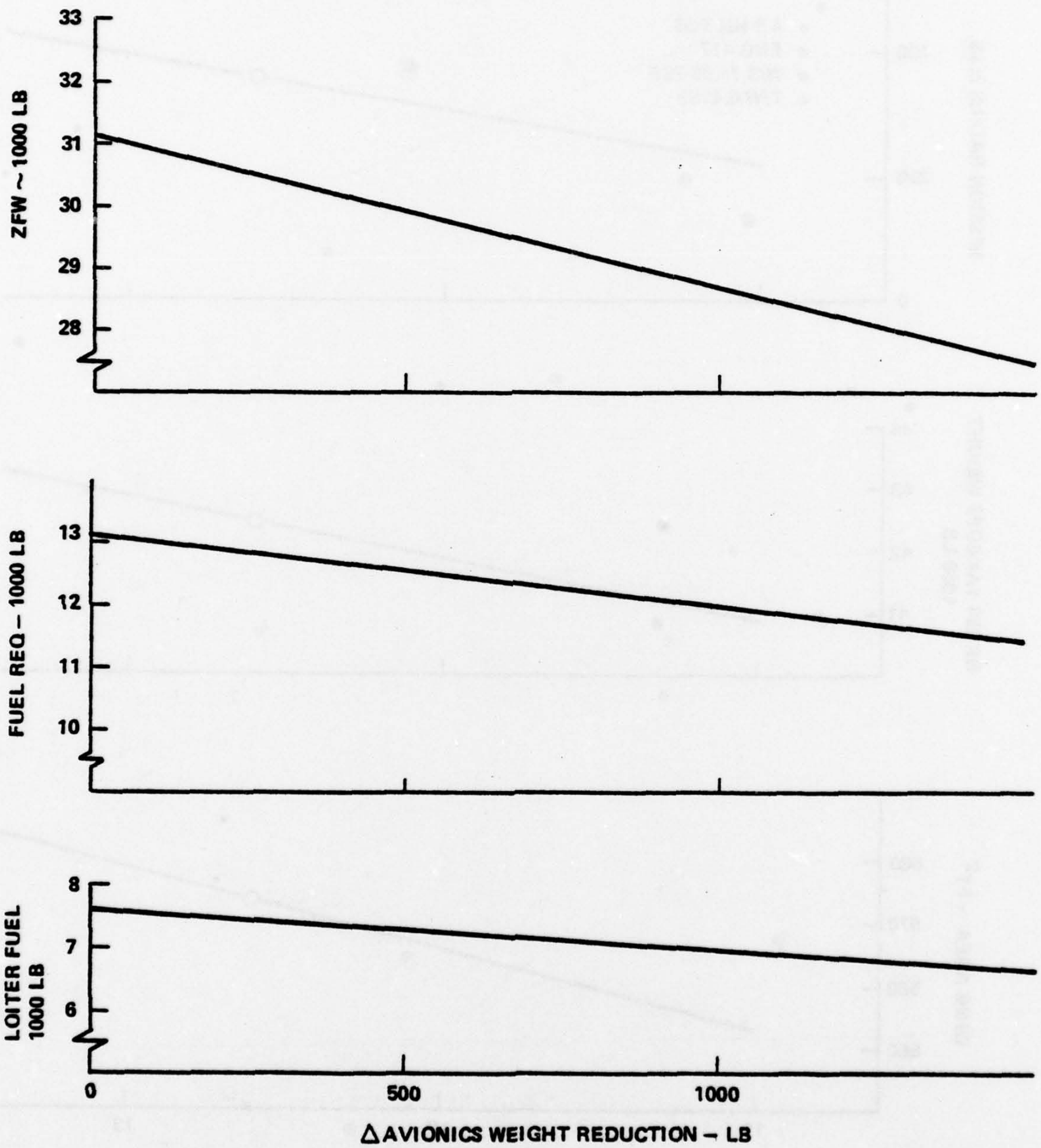


Figure 2-28. Effect of Avionics System Reduction on S-3A Size

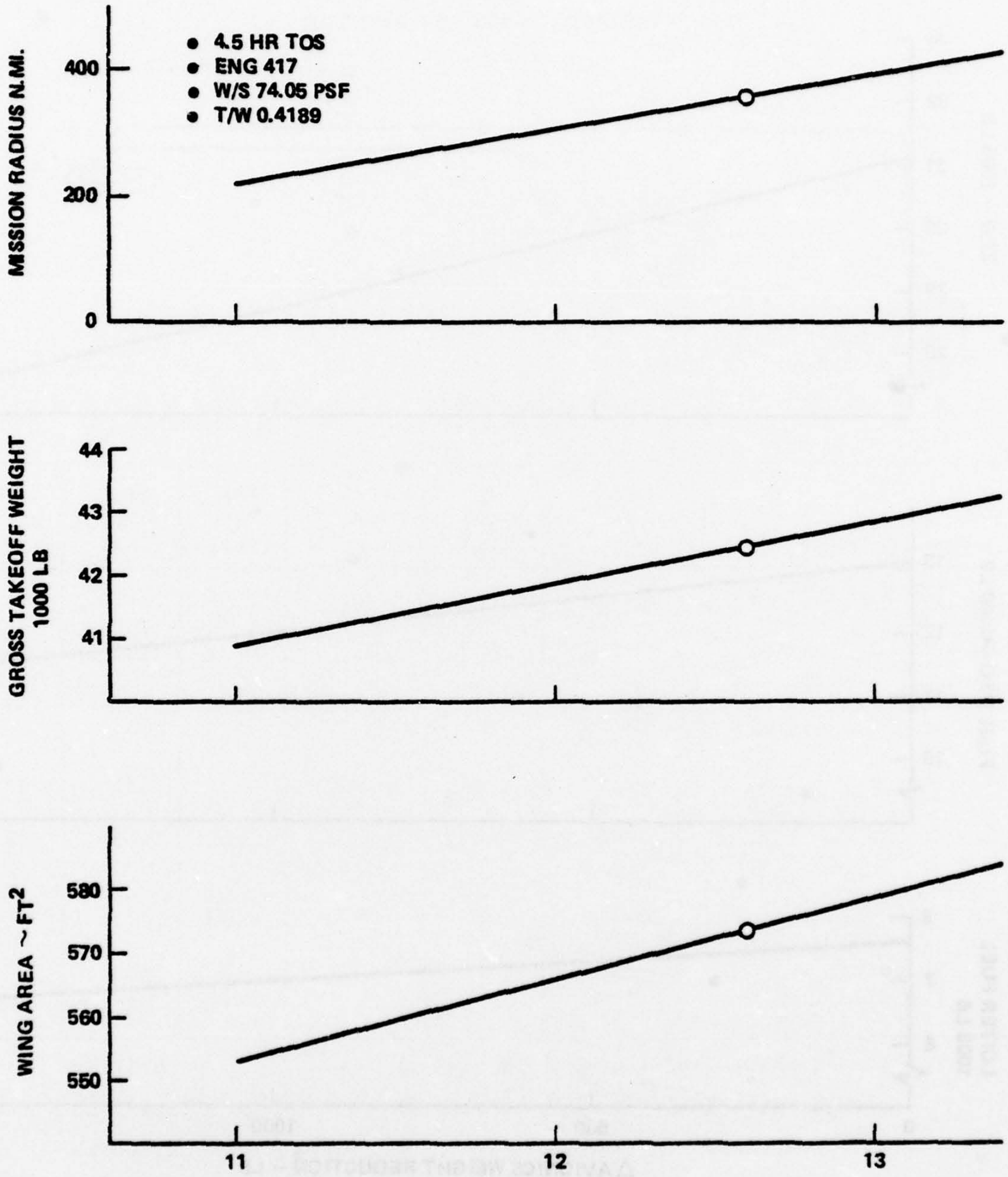
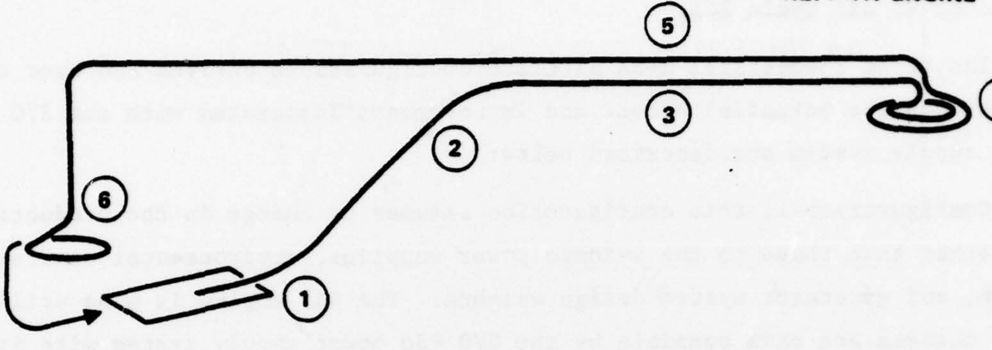


Figure 2-29. Effect of Reducing Avionics Payload on S-3A Size (-500 lb reduction)

TABLE 2-59. S-3, ASW SEARCH AND ATTACK MISSION, LOADING "D"
(VARIANT C -500 LBS PAYLOAD)

REF: 417 ENGINE



Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-up & Takeoff	42,486	-	0	0.08	441	-
2. Climb	42,045	220	0	0.32	1101	98
3. Cruise Out at Optimum Altitude	40,944	356	37,000	0.73	1257	258
4. Loiter on Station	39,687	370	39,000	4.5	7281	0
5. Cruise Back at Optimum Altitude	32,406	354	40,000	1.01	1415	356
6. Reserve Loiter	30,991	160	0	0.33	475	-
5% Initial Fuel Reserve	-	-	-	-	630	-

Totals:	Mission Time (Items 2 through 5)	6.57 Hr
	Mission Fuel (Items 1 through 5)	11,495 Lb
	Fuel Load	12,600 Lb
	Radius of Operation	356 NM

For reference purposes, the avionic suite in the baseline S-3A is air cold plate cooled by 80^{o}F cabin air and by ambient (103^{o}F maximum) forced air. The cabin air is provided by engine compressor bleed air and APU air and is cooled by an air cycle ECS.

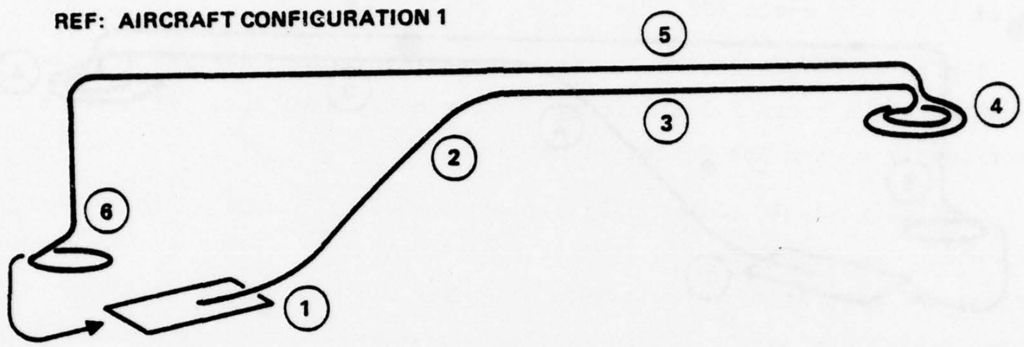
The three theoretical S-3A aircraft configurations derived and used to demonstrate the potential effect and improvements associated with the 270 Vdc power supply system are described below:

Configuration 1, this configuration assumes no change in the production S-3A other than those to the avionic power supplies, environmental control system, and generator system design weights. The 417 engine is also utilized. These changes are made possible by the 270 Vdc power supply system with its resulting improvements and consequent reduction in generator power extraction and ECS engine bleed air flow. The associated weight reduction is estimated to be 400 pounds. This configuration was used to generate the mission performance data shown in Tables 2-60 and 2-61.

Configuration 2, this configuration is a hypothetical S-3A which not only includes the improvements of Configuration 1 above but has additionally been optimized (sized down) as a function of the growth factor relative to the airframe. This sizing down was accomplished to fully exploit the weight reduction to the avionic power supplies, ECS, and generator subsystems resulting from utilization of the 270 Vdc power system, while maintaining the basic mission as the limiting criteria. The potential weight reduction of this configuration is also estimated to be 400 pounds and its mission performance data is shown in Table 2-62.

Configuration 3, this configuration is the same hypothetical, growth factored S-3A as Configuration 2 above with the exception that the air cycle ECS has been replaced by a vapor cycle (Freon)ECS. The estimated weight reduction of this configuration is 485 pounds and its mission performance data is shown in Table 2-63.

TABLE 2-60. BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D", -400 LBS PAYLOAD
(MISSION VARIANT A)

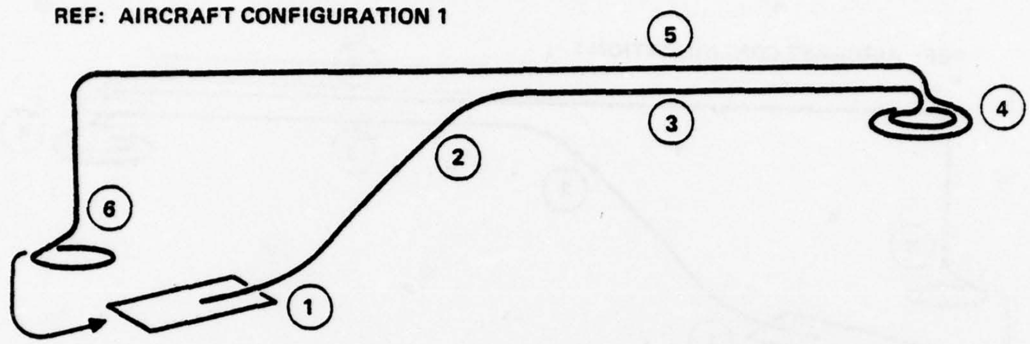


Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-up & Takeoff	43,886	-	0	0.08	460	-
2. Climb	43,426	220	0	0.32	1138	98
3. Cruise Out at Optimum Altitude	42,326	355	36,500	0.73	1285	258
4. Loiter on Station	41,035	370	38,000 to 40,000	4.57	7668	0
5. Cruise Back at Optimum Altitude	33,335	335	40,000	1.02	1441	356
6. Reserve Loiter	31,894	160	0	0.33	493	-
5% Initial Fuel Reserve	31,401	-	-	-	657	-

Totals:
- Mission Time (Items 2 through 5): 6.65 Hr
- Mission Fuel (Items 1 through 5): 11,992 Lb
- Fuel Load: 13,142 Lb
- Radius of Operation: 356 NM

TABLE 2-61. BASELINE S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D", -400 LBS PAYLOAD

(MISSION VARIANT B)

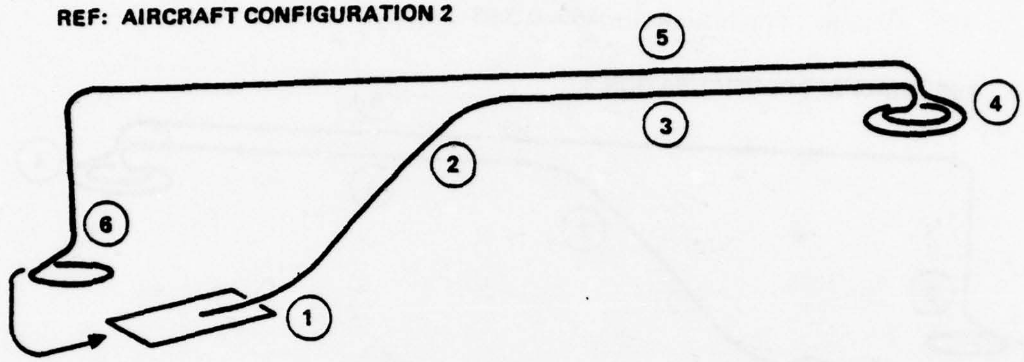


Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-up & Takeoff	43,886	-	0	0.08	460	-
2. Climb	43,426	220	0	0.32	1138	98
3. Cruise Out at Optimum Altitude	42,288	355	36,300	0.77	1356	272
4. Loiter on Station	40,932	370	38,000 to 40,000	4.5	7537	0
5. Cruise Back at Optimum Altitude	33,395	355	40,000	1.06	1499	372
6. Reserve Loiter	31,896	160	0	0.33	495	-
5% Initial Fuel Reserve	31,401	-	-	-	657	-

Totals:	Mission Time (Items 2 through 5)	6.66 Hr
	Mission Fuel (Items 1 through 5)	11,990 Lb
	Fuel Load	13,142 Lb
	Radius of Operation	372 NM

TABLE 2-62. OPTIMIZED S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D" WT - 400 LBS PAYLOAD

REF: AIRCRAFT CONFIGURATION 2

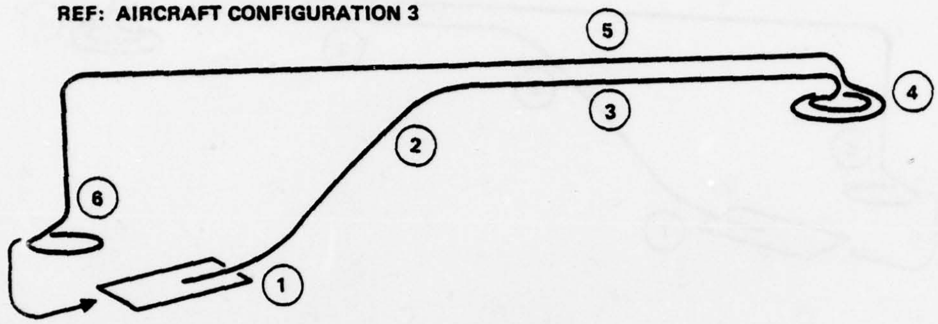


Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-Up & Takeoff	42,848	-	0	0.08	443	-
2. Climb	42,405	220	0	0.32	1110	99
3. Cruise Out at Optimum Altitude	41,297	356	36,100	0.73	1244	257
4. Loiter on Station	40,051	370	38,000 to 40,000	4.5	7360	0
5. Cruise Back at Optimum Altitude	32,691	354	40,000	1.02	1413	356
6. Reserve Loiter	31,278	160	0	0.33	478	-
5% Initial Fuel Reserve	30,800	-	-	-	634	-
Totals: Mission Time (Items 2 through 5)						6.57 Hr
Mission Fuel (Items 1 through 5)						11,570 Lb
Fuel Load						12,683 Lb
Radius of Operation						356 NM

TABLE 2-63. OPTIMIZED S-3A, ASW SEARCH AND ATTACK MISSION, LOADING "D",

WT - 485.0 LBS PAYLOAD

REF: AIRCRAFT CONFIGURATION 3



Mission Segment	Init Wt (Lbs)	Avg Speed (KTS)	Init Alt (Feet)	Seg Time (Hrs)	Seg Fuel (Lbs)	Gnd Dist (N.M.)
1. Warm-Up & Takeoff	42,540	-	0	0.08	441	-
2. Climb	42,099	220	0	0.32	1100	99
3. Cruise Out at Optimum Altitude	40,999	355	36,100	0.73	1256	257
4. Loiter on Station	39,743	370	38,000 to 40,000	4.5	7276	0
5. Cruise Back at Optimum Altitude	32,467	356	40,000	1.02	1414	356
6. Reserve Loiter	31,053	160	0	0.33	475	-
5% Initial Fuel Reserve	30,578	-	-	-	630	-

Totals:	Mission Time (Items 2 through 5)	6.57 Hr
	Mission Fuel (Items 1 through 5)	11,487 Lb
	Fuel Load	12,592 Lb
	Radius of Operation	356 NM

Review of the data presented in Tables 2-60 and 2-61 as compared to the baseline (Table 2-55) will reveal that application of the 270 Vdc power system to the baseline S-3A aircraft with the subsequent improvement to generator power extraction, dc power supplies and reduction of ECS bleed air flow will result in (1) an increase to the time on station of 0.07 hours (radius of operation constant, reference Table 2-60 or (2) an increase to the radius of operation of 16 nautical miles (TOS constant, reference Table 2-61).

Tables 2-62 and 2-63 depict the more significant improvements in GTOW and fuel usage of the hypothetically optimized (sized down) S-3A's utilizing the application and improvements of the 270 Vdc power system in conjunction with air cycle and vapor cycle environmental control systems respectively.

2.8 LIFE CYCLE COSTS

Previous discussions have developed and defined efficiency, weight, reliability, and fuel consumption improvements resulting from the utilization of 270 Vdc power supplies in lieu of the 400 Hz power supplies presently in common use. On the surface, it is difficult to visualize the numerous trade-off studies involved in this process to ensure minimum cost of ownership for each aircraft configuration considered. For example, would it be more cost effective to increase the power supply weight and volume to achieve higher reliability, thus reducing maintenance costs and increasing fuel consumption, or would it be more cost effective to minimize weight and volume, thus reducing fuel consumption and experiencing lower reliability and increased maintenance costs? Where is the optimum design point? In order to evaluate these dissimilar study elements (weight, reliability, maintenance costs, fuel consumption, etc.) and determine the relative cost of ownership, a common denominator, LCC, was used to optimize each trade-off conducted during this study.

LCC studies were performed on three S-3A aircraft configurations and two V/STOL configurations with similar mission requirements. The cost elements considered for each trade-off study included but were not limited to the following:

- Initial power supply cost (270 Vdc design)
- Initial ECS cost (new unit)
- Initial electrical system cost (new system)
- Resized aircraft cost
- Reliability (MTBMA)
- Maintenance cost
- Fuel cost

2.8.1 Life Cycle Cost Parameters

The parameters used in LCC studies included only those parameters directly affected by hardware changes resulting from the replacement of the standard 115/200V, 400 Hz power system with a 270 Vdc power system. Table 2-64 lists these parameters and their values for each aircraft configuration considered, plus those airplane coefficients (growth factor, aircraft life, fuel fraction, flight time, MTBMA, GTOW cost/pound, maintenance action cost, etc.) necessary to determine LCC impact.

The airplane configurations considered included:

- Present S-3A: Baseline established for significant LCC elements affected by the introduction of a 270 Vdc primary power system.
- 270 Vdc Power System (Configuration 2): Aircraft weight reduced to reflect new avionic weight and reduced ECS, electrical system, and engine requirements resulting from the use of a 270 Vdc primary aircraft power system. Cooling is accomplished by air cycle ECS.
- Vapor Cycle Cold Plate Cooling (Configuration 3): Aircraft size reduced to reflect 270 Vdc power system, vapor cycle ECS, electrical system, and engine requirements.
- V/STOL Baseline: Baseline established for LCC study using 115/220V, 400 Hz primary power technology.
- V/STOL: Aircraft weight reduced to reflect new avionic, vapor cycle ECS, electrical system, and engine requirements which resulted from the use of a 270 Vdc primary aircraft power source.

The data required to make these relative LCC calculations were generated in previous sections or are standard Navy-accepted averages. Power supply and electrical system costs are assumed to have little or no change for each of the resized or "rubber aircraft" considered, and design and development cost for either 400 Hz or 270 Vdc power sources are assumed to be equal or similar; therefore, no values are entered.

TABLE 2-64. LIFE CYCLE COST PARAMETERS

Symbol	Parameter	Present S-3A	S-3A 270Vdc PS	S-3A Vapor Cycle	V/STOL (400 Hz)	V/STOL 270 Vdc
C_a	Power Supply Cost ($)	0	0	0	0	0
C_e	ECS Cost ($)	167,913	154,305	90,639	137,781	74,358
C_ℓ	270 Vdc Elec. Sys. Cost ($)	0	0	0	0	0
C_p	GTOW Cost/lb	300	300	300	352	352
C_m	Cost/Maint. Action ($)	2,215	2,215	2,215	2,215	2,215
C_f	Fuel Cost/lb ($)	0.15	0.15	0.15	0.15	0.15
W_a	Power Supply Wt. (lb)	847	579	574	696	475
W_e	ECS Weight (lb)	691	635	373	567	306
W_f	Fuel Weight (lb)	1,060	990	653	796	516
W_ℓ	Elec. Sys. Weight (lb)	831	756	938	682	769
MTBMA	$\frac{\text{MTBF}}{2}$ (hr)	69	141	345	84	421
F	Growth Factor	3.6	3.6	3.6	3.8	3.8
F_f	Fuel Fraction	0.27	0.27	0.27	0.19	0.19
H_ℓ	Aircraft Life (hr)	13,500	13,500	13,500	10,800	10,800
$2H_\ell$	Equip. of Life (hr)	27,000	27,000	27,000	21,600	21,600
H_f	Flight Time (hr)	6.57	6.57	6.57	3.8	3.8

2.8.2 Life Cycle Cost Computations

LCC variations for the 270 Vdc power study were considered to exist primarily in four identifiable cost areas: equipment cost (C_t), repair cost (C_r), aircraft cost (C_{ac}), and fuel cost (C_f). Therefore, the LCC can be determined for each aircraft configuration by

$$LCC = C_t + C_r + C_{ac} + C_f$$

The individual terms of this expression are defined as follows:

- Equipment cost (C_t) includes the cost of avionic power supplies (C_a), environmental control system (C_e), and the 270 Vdc primary power system (C_ℓ).

$$C_t = C_a + C_e + C_\ell \tag{2}$$

- Repair cost (C_r) includes two major elements, equipment maintenance rate $\left(\frac{1}{MTBMA}\right)$ and the average cost per maintenance action. Life cycle repair costs were calculated by

$$C_r = \frac{2H_\ell \times C_m}{MTBMA} \tag{3}$$

where; H_ℓ is aircraft life in estimated flight hours.

$2H_\ell$ is estimated operating life of avionic equipment.

C_m is cost per maintenance action.

MTBMA is mean time between maintenance actions.

$$\left(MTBMA = \frac{MTBF}{4}\right)$$

- Aircraft cost (C_{ac}) includes the aircraft growth factor, average aircraft cost per pound, and the weight of aircraft elements affected by the 270 Vdc conversion. Aircraft cost was computed by

$$C_{ac} = (F-1) \times C_p \times (W_a + W_e + W_f + W_\ell) \tag{4}$$

where:

F is the aircraft growth factor

C_p is the average airframe cost per pound of GTOW

W_a is avionic power supply weight

W_e is ECS weight

W_f is fuel weight

W_ℓ is electrical system weight

- Fuel cost (C_f) included only those items whose change affected fuel consumption

$$C_f = W_f + F \times F_f \ (W_a + W_e + W_f + W_\ell) \quad \frac{P_f \ H_\ell}{H_f} \tag{5}$$

where:

F_f is the fuel fraction

P_f is the purchase of one pound of fuel

H_f is the number of hours per flight

Computations for each "rubber" airplane considered are tabulated in Table 2-65 and presented graphically in Figure 2-30.

TABLE 2-65. LIFE CYCLE COST SUMMARY

LCC Element	S-3A 270 Vdc Power Supply	S-3A Vapor Cycle	V/STOL Vapor Cycle
C_t (Equip't.cost)	-\$13,608	-\$77,274	-\$63,423
C_r (Repair cost)	-442,590	-693,391	-459,228
C_{ac} (A/C cost)	-368,719	-693,955	-665,280
C_f (Fuel cost)	-162,083	-392,380	-327,137
LCC Savings	\$ 987,000	\$1,857,000	\$1,515,000

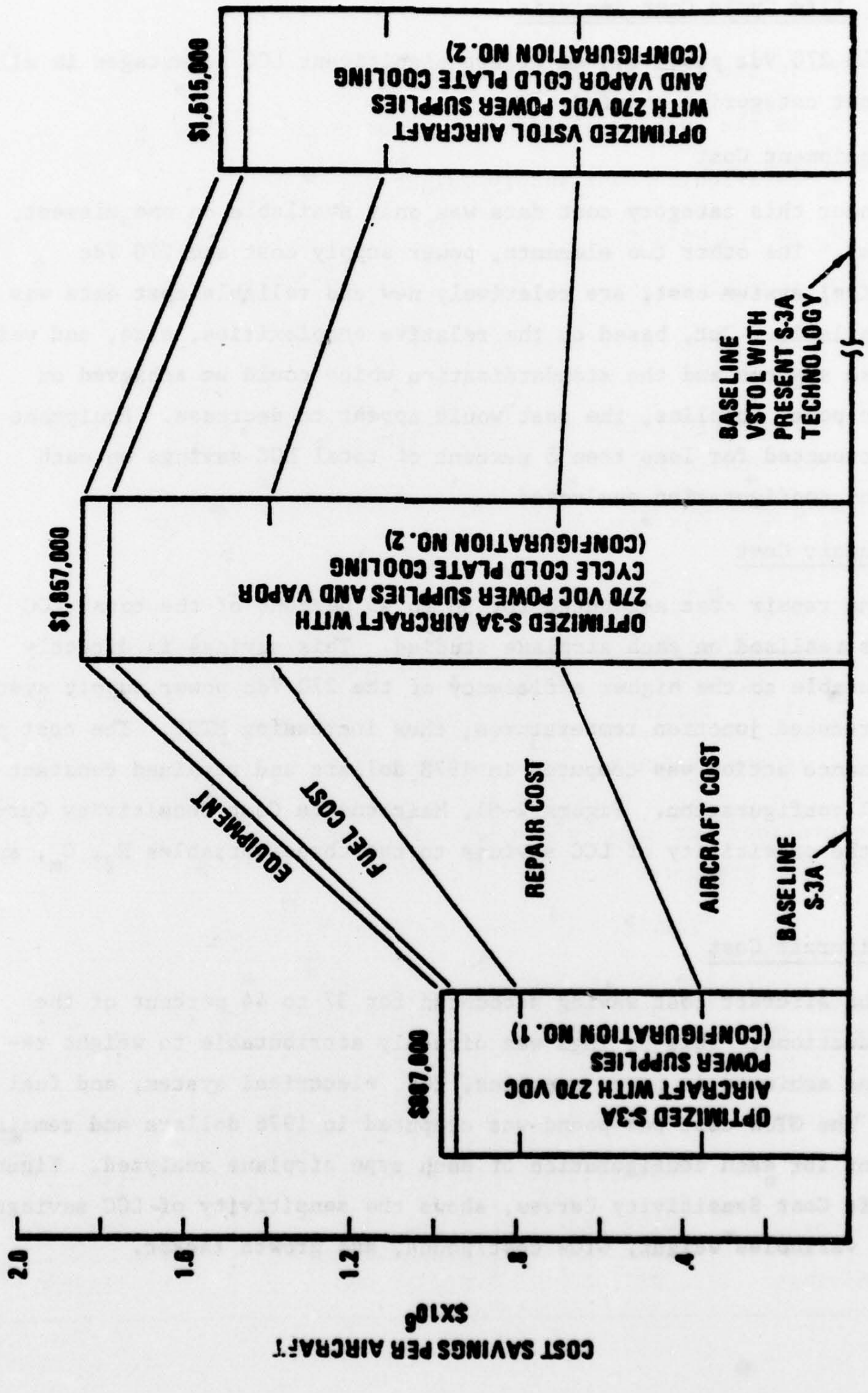


Figure 2-30. Aircraft Life Cycle Cost Savings from Application of New Technology

2.8.3 Life Cycle Cost Analysis

The 270 Vdc power system offers significant LCC advantages in all four cost categories studied.

Equipment Cost

Under this category cost data was only available on one element, ECS cost. The other two elements, power supply cost and 270 Vdc electrical system cost, are relatively new and reliable cost data was not available. But, based on the relative complexities, size, and weight of these systems and the standardization which could be achieved on 270 Vdc power supplies, the cost would appear to decrease. Equipment cost accounted for less than 5 percent of total LCC savings on each airplane configuration evaluated.

Repair Cost

The repair cost accounted for 30 to 45 percent of the total LCC savings realized on each airplane studied. This savings is directly attributable to the higher efficiency of the 270 Vdc power supply system which reduced junction temperatures, thus increasing MTBF. The cost per maintenance action was computed in 1978 dollars and remained constant for all configuration. Figure 2-31, Maintenance Cost Sensitivity Curves, shows the sensitivity of LCC savings to the three variables H_{ℓ}, C_m, and MTBMA.

Aircraft Cost

The aircraft cost saving accounted for 37 to 44 percent of the LCC reductions. This savings was directly attributable to weight reductions achieved in power supplies, ECS, electrical system, and fuel load. The GTOW cost per pound was computed in 1978 dollars and remains constant for each configuration of each type airplane analyzed. Figure 2-32, Aircraft Cost Sensitivity Curves, shows the sensitivity of LCC savings to the variables weight, GTOW cost/pound, and growth factor.

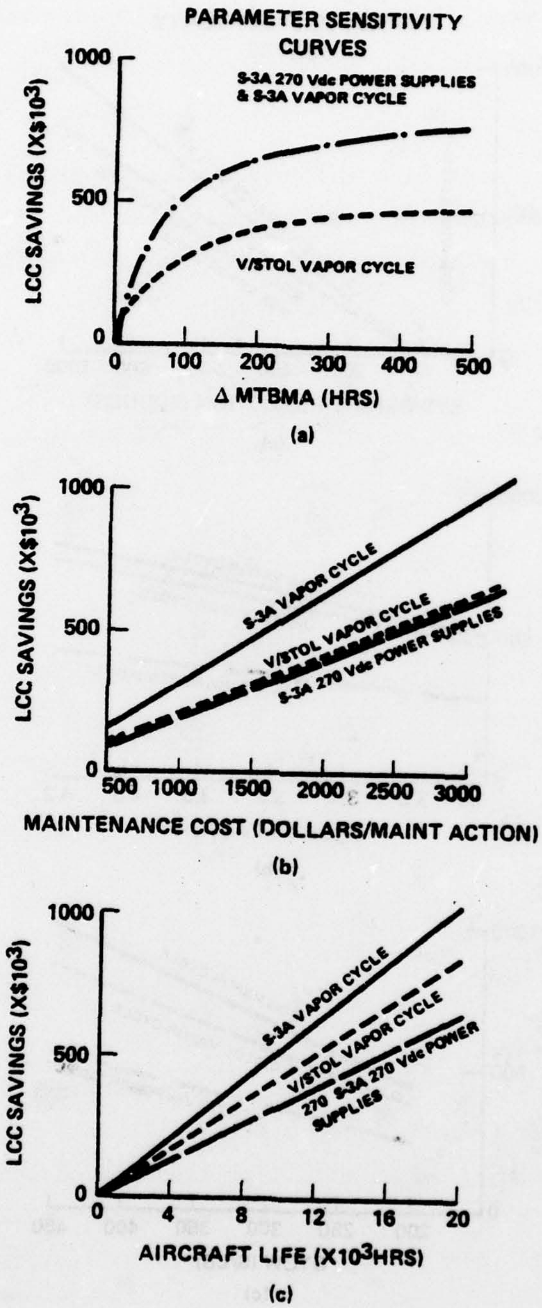


Figure 2-31. Life Cycle Maintenance Cost Savings

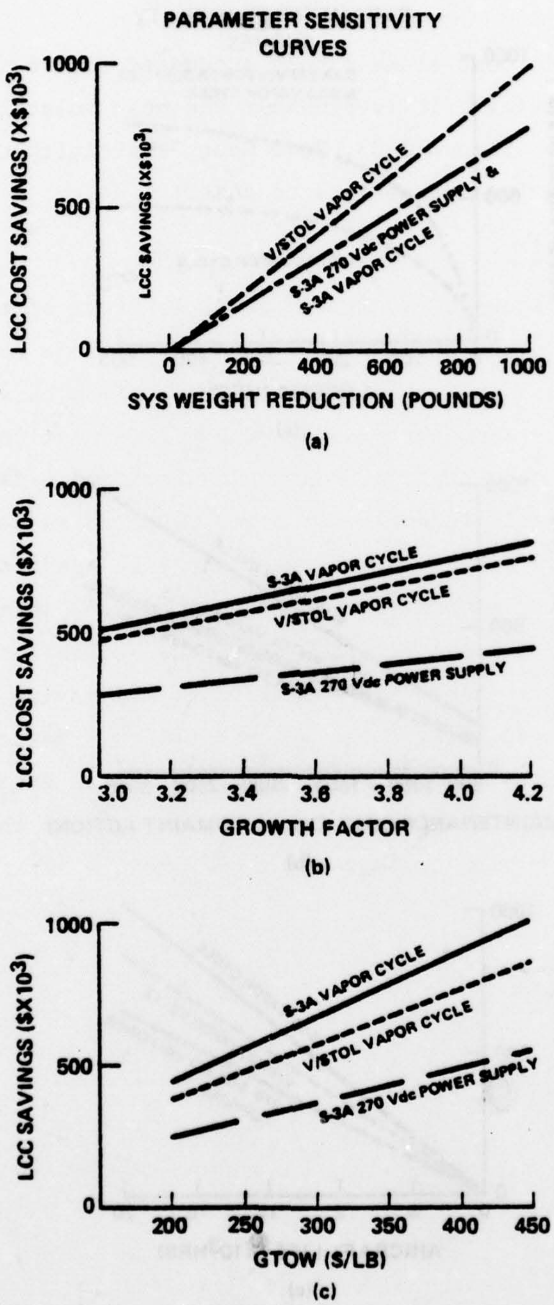


Figure 2-32. Life Cycle Aircraft Cost Savings

Fuel Costs

Although this cost element only accounted for 16 to 21.5 percent of the total cost savings, it is probably the most volatile because of the world oil crisis. Figure 2-33, Fuel Cost Sensitivity Curves, shows the sensitivity of various parameters to cost.

LCC Sensitivity

Figure 2-34 shows sensitivity curves for four of the more volatile parameters used in the airplane LCC study. Airframe cost per pound, curve a, shows relatively equal cost differentials between the three aircraft configurations considered, with V/STOL cost saving appearing almost midway between the two S-3A configurations, S-3A vapor cycle and V/STOL vapor cycle include 270 Vdc power supplies as well as vapor cycle cooling. Fuel cost, curve b, allows reasonable prediction of addition LCC changes resulting from changes in fuel cost. Curve c shows MTBMA variations of ±50 percent from the calculated norms for each aircraft, and thus allows reasonable approximation of LCC saving when new technologies are introduced into the avionic system. Maintenance costs include all services, spares, test equipment, real estate, etc. associated with the repair of a single end item. Curve d shows the effect of maintenance costs from $500 to $3,000 per each module repair action at the IMA level.

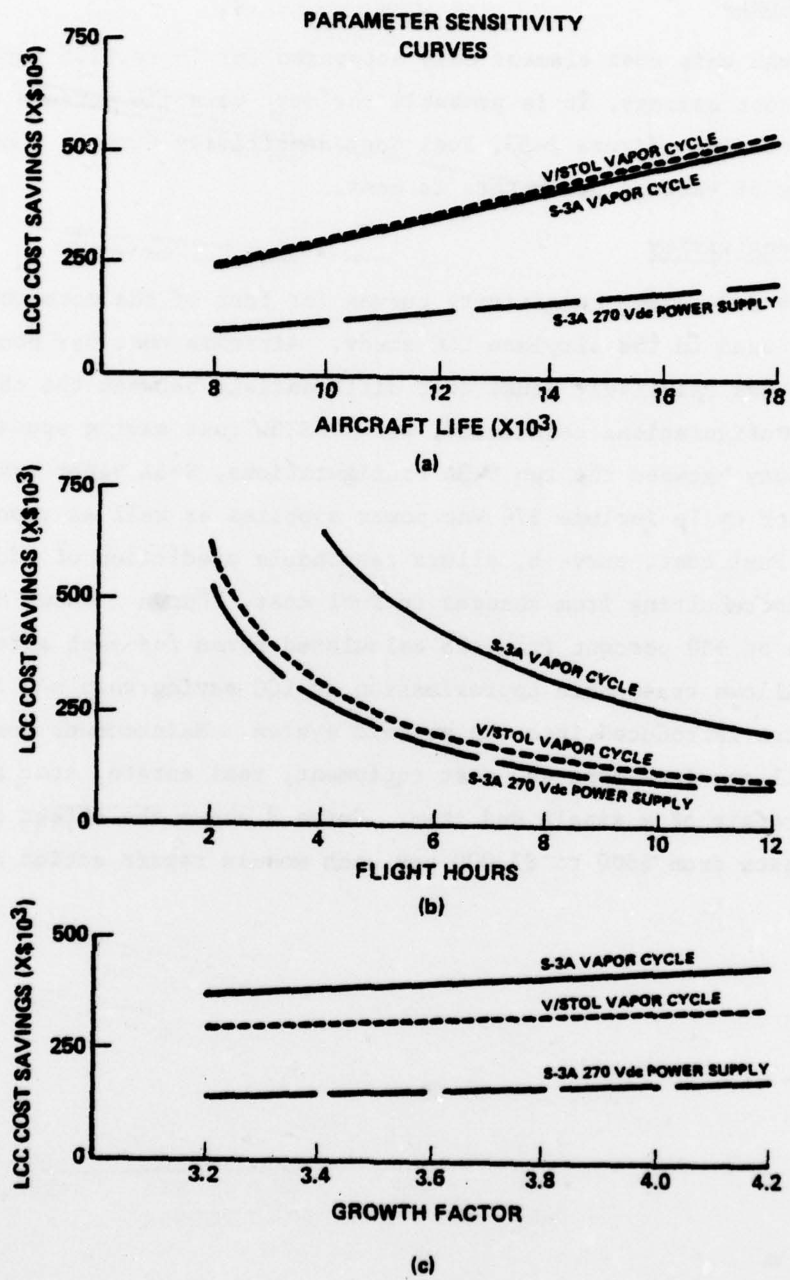


Figure 2-33. Life Cycle Fuel Cost Savings (Sheet 1 of 2)

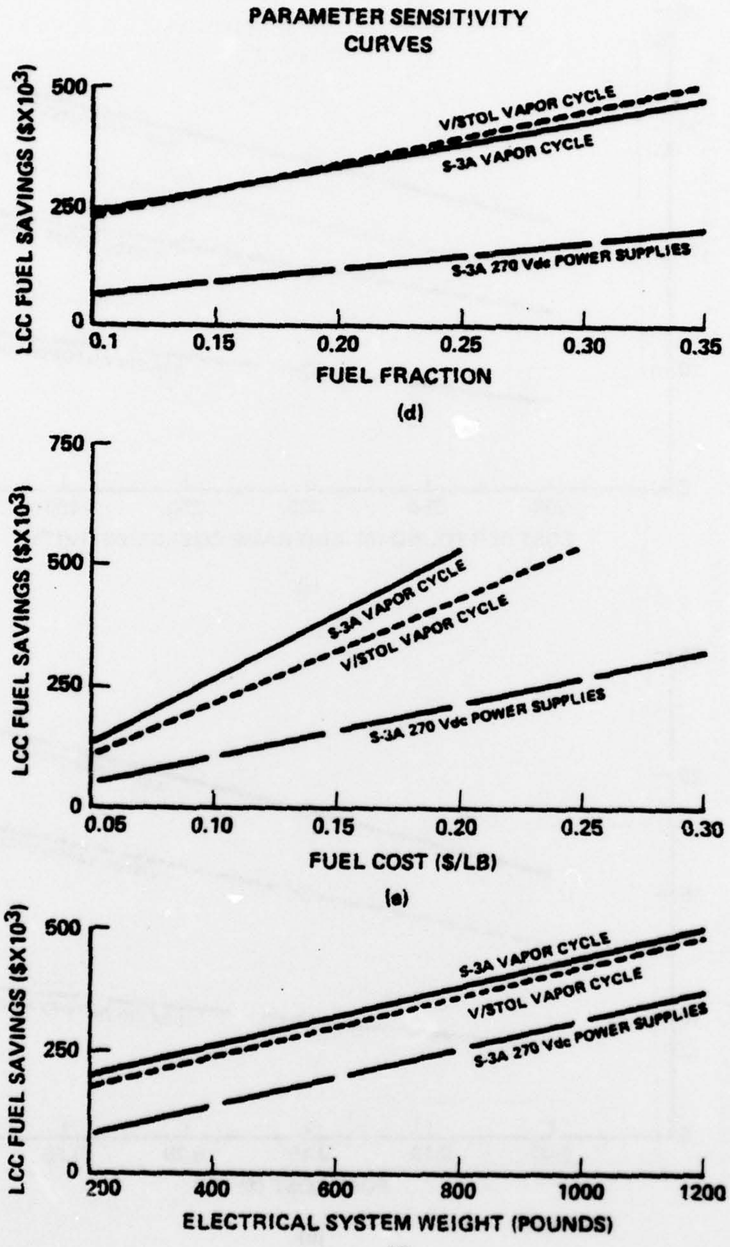
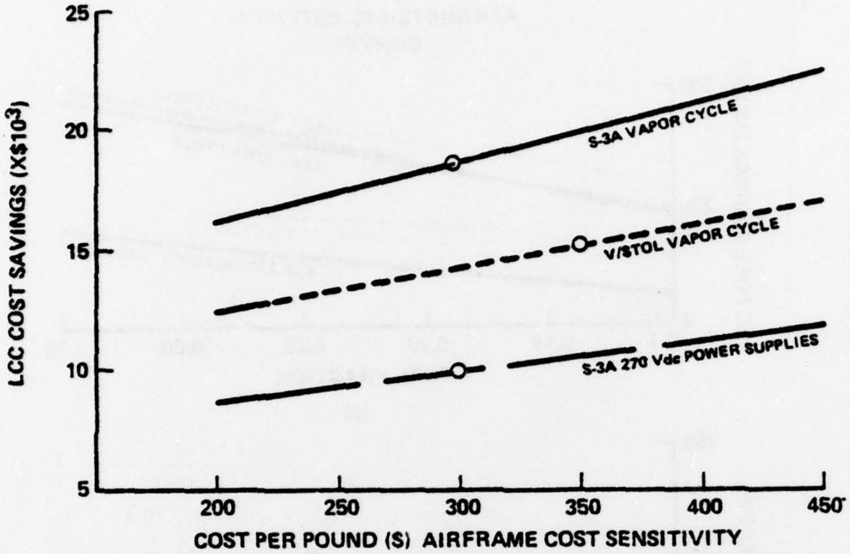


Figure 2-33. Life Cycle Fuel Cost Savings (Sheet 2 of 2)



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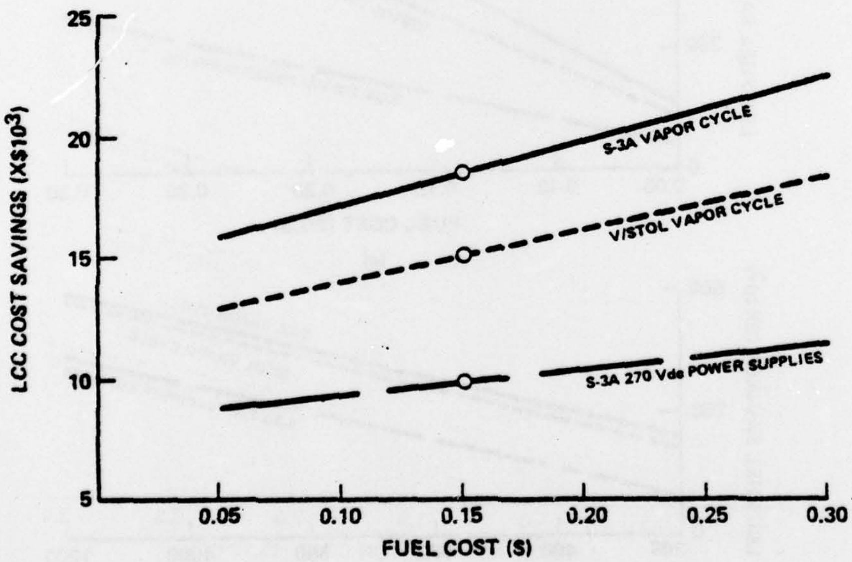
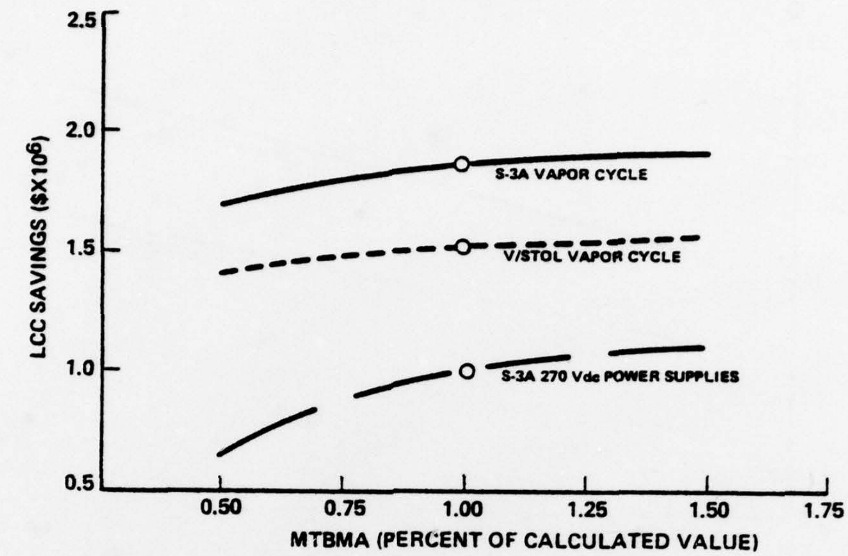


(b)

Figure 2-34. Airplane Life Cycle Cost Sensitivity (Sheet 1 of 2)



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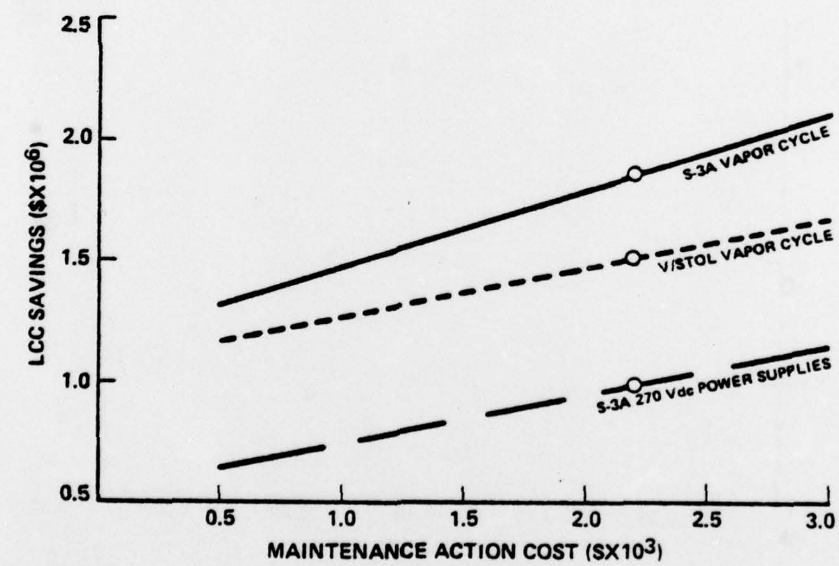

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Figure 2-34. Airplane Life Cycle Cost Sensitivity (Sheet 2 of 2)

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The objective of this analysis was to determine the total platform impact on an S-3A avionic suite outfitted with 270 V DC switched mode regulators in lieu of standard 115/200V, 400 Hz transformer coupled series regulators and to quantify the resulting impact in terms of changes to aircraft weight, mission performance, fuel usage, reliability, and LCC.

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